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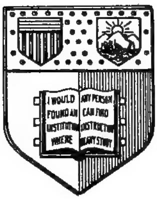
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A HISTORY OF
BRITISH MAMMALS

by

Gerald E. H. Barrett-Hamilton

VOL. II.

LAND MAMMALS

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The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names have been supplied by Mr C. H. Alston. Valuable assistance has been rendered by Mr M. C. A. Hinton regarding extinct Mammals.

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FULL-PAGE (*Black and White*).

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Greater Horseshoe Bats (*do.*).
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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

Pygmy or Lesser Shrews. (*Coloured.*)
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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

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FULL-PAGE (*Black and White*).

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ILLUSTRATIONS

FULL-PAGE (*Black and White*).

Scottish Blue Hare.

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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

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ILLUSTRATIONS

FULL-PAGE (*Black and White*).

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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

Orkney Grass Mice (*coloured*).
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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

British *Microtinæ* (Skins); (1, 2) *Arvicola amphibia amphibia*; (3) *A. a. reta*; (4, 5) *Evotomys glareolus*; (6, 7) *E. skomerensis*. (*Coloured*).
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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

British *Microtinæ* (Skins); (1) *Microtus hirtus;* (2) *M. agrestis neglectus;* (3) *M. orcadensis;* (4) *M. agrestis exsul.* (*Coloured.*)
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ILLUSTRATIONS

FULL-PAGE (*Black and White*).

The Field Mouse (*Apodemus sylvaticus*). (1) Left Ear; (2 and 2*a*) Left Hand; (3 and 3*a*) Left Foot. (Three times life size.)

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ILLUSTRATIONS

FULL-PAGE (*Coloured and Black and White*).

British *Muridæ* (Skins). *Coloured.*

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ILLUSTRATIONS

FULL-PAGE (*Black and White*).

The Common Rat—*Epimys novegicus.* (1) Left Ear; (2) Left Hand; (3) Left Foot.

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ILLUSTRATIONS

FULL-PAGE.

Skins of British Squirrel—*Sciurus leucourus*. (*Coloured.*)

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The English local names have been revised in part by Mr W. W. Skeat, M.A. (assisted by the late Professor W. W. Skeat), and in part by Mr C. M. Drennan, M.A. Lond., late Scholar Emm. Coll. Camb.; the Celtic and Gaelic names by Dr E. S. Quiggin, M.A., Ph.D., Fellow and Lecturer in Modern Languages and Celtic of Gonville and Caius College, Cambridge; while a list of Scottish Gaelic names has been supplied by Mr C. H. Alston. Much information has been taken from Mr G. S. Miller's recently published "Catalogue of the Mammals of Western Europe," the use of the MS. and proofs of which before publication was kindly permitted by the Trustees of the British Museum of Natural History.

ILLUSTRATIONS

FULL-PAGE.

The British Squirrel—*Sciurus leucourus.*
Hands and Feet of the Squirrel.

FIGURES IN TEXT.

Skull of Squirrel—*Sciurus vulgaris.*
Spoor of Squirrel in Snow.

INSECTIVORA.

INSECT-EATING MAMMALS.

THE five British members of this order are comprised in four genera, viz. :—*Talpa*, represented by the Mole ; *Erinaceus*, by the Hedgehog ; *Sorex*, by the Common and Pygmy Shrews ; and *Neomys*, by the Water Shrew. Of these the Hedgehog and Pygmy Shrew are alone found in all three sections of the kingdom. The Mole, Common Shrew, and Water Shrew, although common in Great Britain, are unknown in Ireland.

These four genera are typical of as many families, and since in dealing with them there arises no question of super-generic importance affecting British natural history, it seems best to shorten the introduction to this order and to omit all technical descriptions of the families. This course leaves more space for the ampler treatment demanded by more difficult groups, such as bats, rodents, seals, and whales.

To non-technical eyes the British insectivora, excepting the shrews, present few points of resemblance, and even the characteristic to which they owe the name of their order is not absolute, since, although restricted as a whole to a diet of invertebrates, they have no objection to attack and devour the higher animals when an opportunity occurs. In fact, the Hedgehog is in this respect a frequent, the Water Shrew an habitual, offender ; and for the others, the limits of their menu are probably in this respect governed rather by their lack of power than by any lack of relish for flesh. As mentioned in detail under the various species, some insectivores will even eat vegetable matter, when no other food is available.

Each family consists of a highly specialised and ancient group, with no near allies of any sort in Britain.

The semi-blind, burrowing Mole, its whole frame adapted for a life spent in pursuit of earthworms ; the comparatively inactive Hedgehog, hunting its humble prey in the midst of enemies, and relying for its own safety on the passive defence of a coat of spines ; and the shrews, always lively and alert whether on land or water—are each unique types in the British fauna. The shrew and the Mole are active throughout the year, whereas the Hedgehog undergoes at least a partial hibernation during the colder months.

The Pygmy Shrew is remarkable for being the smallest non-volant British mammal, and in this respect it has few rivals, and none outside its own order, throughout the world.

Shrews, hedgehogs, and moles are well known in literature, and stand for well-defined and characteristic types in the public mind.

Besides the genera mentioned above as British, there are found in continental Europe, the white-toothed shrews of the sub-family *Crocidurinæ*, which are numerous in species and widely distributed in Asia and Africa. The desmans (genus *Desmana*, Göldenstädt, 1777, ante-dating *Mygale*, G. Cuvier, 1800, and *Galemys*, Kaup, 1829), which were formerly more widely distributed and included Britain in their range, are now in Europe confined to southern Russia, with the Pyrenees and the Iberian Peninsula, where there are at least two species. They are inhabitants of streams and rivers, and their habits are said to resemble those of the water rats, with the difference that they feed, not on vegetable matter, but on invertebrates.

The order insectivora is extremely old, being of pre-Pliocene age, both in Europe and America. Further details will be found under the several genera and species.

TALPIDÆ.

TRUE MOLES.

GENUS TALPA.

1758. TALPA, Carolus Linnæus, *Systema Naturæ*, x., 52; xii., 73, 1766: based on *T. europæa* of Linnæus, and *T. asiatica* of Linnæus.

In Britain this genus includes only the well-known *T. europæa*, the type of its genus, of form and habits so characteristic as to require few words of description.

True moles are burrowing insectivores, with the body cylindrical, short limbs and tail, and immense hands; with abundant velvety fur set vertically in the skin; with eye and ear very much reduced or entirely absent as external organs; with the head, which is used for turning up the earth, tapering to the extremity of the slender, flexible, and sensitive snout.

The **arm** is modified so as to form a powerful digging organ; the radius and ulna are well developed, short, and strong; the humerus and clavicle are short and broad, the latter particularly so, thus bringing the arm well forward. The hand is very broad and flat, and, when digging, faces outwards, not downwards (Plates I. and II., Fig. 1); it cannot be closed, but by inclination of the terminal phalanges forms a very efficient hoe; its great breadth arises principally from a special development of the proximal inner wrist-bone or radial sesamoid, a large curved ossicle known as the *os falciforme*. All five fingers are present and carry strong, acutely-pointed claws, which are firmly embedded in the elongated terminal phalanges. The other phalanges are much shortened. In the hind limb the tibia and fibula are united, and there is no pubic symphysis. The foot is comparatively small and weak, but all five digits are present. The intestine is without a cæcum.

The **skull** is elongated and possesses auditory bullæ and slender zygomatic arches but no post-orbital processes.

There are forty-four **teeth**, an exceptional number for a recent species, but regarded as typical for the primitive placental mammalia. They are arranged as follows:—

$$i\,\frac{3-3}{3-3},\quad c\,\frac{1-1}{1-1},\quad pm\,\frac{4-4}{4-4},\quad m\,\frac{3-3}{3-3}.$$

The chisel-shaped incisors are disposed in a semicircle; the median upper pair are slightly larger than their fellows, the lower are not extended forwards horizontally as in the shrews. The long and conical upper canine is double-rooted. Then follow three small, subequal, double-rooted premolars; the fourth is larger and more in series with the three molars, of which the second is largest and has seven cusps, two internal and five arranged as an external W (compare Plate II., Fig. 1 A, Vol. I., p. 124). In the lower jaw the canine is indistinguishable from the incisors, and the anterior lower premolar is enlarged to take its place. The premolars are small, but increase in size from the front backwards. The last molar, the smallest of its series, is comparatively larger than that of the upper jaw.

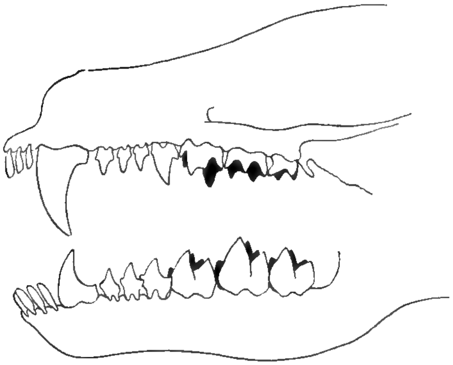

FIG. 1.—SIDE VIEW (diagrammatic and magnified 2⅔ times) OF TEETH OF *Talpa europæa.*

True moles are almost confined to the temperate regions of Europe and Asia, from Great Britain through the Himalaya and Altai ranges to the mountainous parts of Assam and Burma, where they reach at least 10,000 feet (Blanford). The best known species after *T. europæa*, is Savi's *T. cæca* of south Europe except Spain, where is found *T. occidentalis* (Cabrera), a smaller animal with functionless eyes and shorter snout; Thomas's *T. romana*, a large-toothed form, was described from the neighbourhood of Rome, Italy (*Ann. and Mag. Nat. Hist.*, December 1902, 516-517). Others, such as Milne-Edwards's *T. longirostris* of western China and Tibet, the short-tailed *T. micrura* of Hodgson from the south-western Himalayas, and *T. altaica* of Nikolski, from the Altais, are little known. In all, except *T. europæa*, the eyes are said to be covered by a membrane.

The genus is unrepresented in Africa, where its place is taken by the golden moles or *Chrysochloridæ;* and in the new world. In the latter the four allied genera, *Scalops*, *Scapanus*, *Parascalops*, and *Condylura* (see True, *Proc. U.S. Nat. Mus.*, xix. [No. 1101], 1-112, 1896), have the first upper incisor much larger than the second. *Talpa* is connected with *Sorex* through *Urotrichus* and *Neürotrichus*, the mole-shrews of Japan and North America respectively, and through *Uropsilus* of Tibet, the latter a shrew with a mole's skull. Remains of moles occur in the upper Eocene deposits of Europe (*Protalpa*), and the genus *Talpa* itself dates from the Miocene period.

Other allied genera are:—*Scaptochirus*, with forty teeth, of China, Mongolia, Asia Minor, and Syria; *Parascaptor* of Indo-China to Tibet, and *Mogera* of Formosa, Japan, and Siberia, each with forty-two teeth; and the hardly known *Dymecodon* of Japan (see Thomas, *Proc. Zool. Soc.*, London, 4th February 1908, 51, footnote).

THE COMMON MOLE, MOLDWARP OR WANT.

TALPA EUROPÆA, Linnæus.

1758. TALPA EUROPÆA, Carolus Linnæus, *Systema Naturæ*, x., 52; xii., 733, 1766; and all authors, except as below; described from Upsala, Sweden.

1776. TALPA FRISIUS, P. L. S. Müller, *Natursystems Supplements und Register Band*, Suppl., 36; described from Ost-Friesland.

1777. TALPA EUROPÆA, α ALBO-MACULATA, J. C. R. Erxleben, *Systema Regni Animalis*, i., 117; described from Ost-Friesland.

1785. TALPA VULGARIS, P. Boddaert, *Elenchus Animalium*, i., 126; from Brisson, renaming *T. europæa.*

1789. TALPA EUROPÆA, β VARIEGATA, J. F. Gmelin, *Systema Naturæ*, i., ed. xiii., 110; based on a colour-variety.

1789. TALPA EUROPÆA, γ ALBA, J. F. Gmelin, *loc. cit.;* based on a white variety.

1792. TALPA EUROPÆA NIGRA, Robert Kerr, *Animal Kingdom*, 200; apparently renaming *T. europæa.*

1792. TALPA EUROPÆA CINEREA, Robert Kerr, *loc. cit.;* based on a cinereous variety.

1797. TALPA EUROPÆA RUFA, J. M. Bechstein, *Der Zoologe*, i., v.-viii., 13 ; described from southern France.

La Taupe of the French ; *der Maulwurf* of the Germans.

Terminology:—The name "mole," written as *molle* or *mulle*, only appears, according to the New English Dictionary, in Middle English, having been borrowed from Middle Dutch *mol* or *molle* about 1398. This would imply an independent derivation from *mul*, the root of mould, from the Indo-germanic root *mel* = to grind, so that *mulle* meant the "grinder" or "crumbler." But the latter view is only problematic, since there is some evidence to show that "mole" may after all be an English word. Thus, the forms *mallan* or *mullan*, which are given as Irish by O'Reilly, can only have been derived from a similar Anglo-saxon form, since the animal itself did not occur in Ireland.

In any case, the forms *mole* and *moldwarp*, though they come from the same original root, and have been confused in usage, are two totally different words. The two parts of the name *mold-warp* (*molde* = mould, and *weorpan* = to throw) certainly existed separately in Anglo-saxon, although the compound itself has not been discovered. On the other hand, where the word *mold* occurs at a later period, it is not necessarily an abbreviation of *mold-warp*, but may be an independent extension of the form *mole*.

An early and unknown translator (about 1420) of Palladius (*Husbondrie*, Early English Text Society, 108, iv., 130) has:—

> "The molde, and other such as diggeth lowe."

Spenser (1553-1598) uses only *mouldwarp*, but Shakespeare employs both forms, as in *Hamlet*, I., v., 162:—

> "Well said, old mole! canst work i' the earth so fast?"

and again in *Henry IV.* (III., i., 149):—

> "He angers me
> With telling me of the moldwarp and the ant;"

so that the abbreviation, or extension, of the word, whichever view be taken, was of early date. On the other hand, Topsell (1607) has both *mole* and *want*.

Want, *woont*, or *wunt*, which is variously corrupted into *oont*, *hunt*, *wuntit*, etc., is derived, obviously, from Middle English *wont* = a mole, which stood, undoubtedly, for an older form, *wand*, and came from the same root as Anglo-saxon *windan* = to wind. The form *wand* is found in the most ancient English document in existence, viz., the

Epinal Glossary, which has been attributed to about 700 A.D. This is in the Mercian, *i.e.*, Anglian, dialect, but the Saxon form must have been identical with the Anglian, as is known from the history of similarly formed words.

Sex names:—Boar and sow.

Local names (non-Celtic):—*Moldwarp* or *mouldwarp; want* or *wunt;* with innumerable corruptions, of which formidable lists are given in Wright; these are explained under Terminology.

(Celtic):—Irish —*caochán* = "blind one." Scottish Gaelic —*famh-thalmhainn* (*ath-thalmhain*); *dallag* = "blind one"; *dubh-threobhaiche* = "black ploughman"; *ùir-threobhaiche* = "mould-plougher." Manx —*kyaghan* = "blind one"; *roddan-ooirey* = "earth-rat"; *lugh-ghoal* = "blind mouse." Welsh—*gwadd; twrch daear* = "earth hog"; *twrch gorddodyn* = "burrowing hog"; older form, *yllyr.* Cornish—older, *god;* later form, *godh*, *gûdh.*

Mole-hills are known as want-heaves or tumps in various parts of England, both heave and tump being terms having, according to Wright, the general meaning of "heap."

Distribution:—The Common Mole, possibly including forms hitherto undistinguished from it, ranges through boreal and transitional Europe and Asia, from sea-level to about 6000 feet in the Alps (Blasius); and from Scotland, to in Sweden about 59° N. lat. (but not in Norway), the middle Dvina district in north Russia, and corresponding latitudes of Siberia to central France; it there gives way to *T. cæca*, as well as in Dalmatia, Greece, and in most countries south of the Alps. In Spain it is replaced by *T. occidentalis*, and in the neighbourhood of Rome by *T. romana.* Eastwards the limits of its distribution are imperfectly known, but it occurs from Great Britain to probably the Pacific coast of Siberia. In western China, Tibet, the south-western Himalayas, and the Altais it meets other species, already mentioned on p. 5.

In **Great Britain** the Mole is probably abundant in every county of England, Wales, and Scotland.

It is numerous even in Sutherland and Caithness (Harvie-Brown and Buckley), in the former of which Selby reported it as common in 1834 (*Edinburgh New Phil. Journ.*, xx., 159, 1836). The evidence of Scottish naturalists is, however, in favour of a general recent increase in its numbers with a corresponding extension of its range, and there are stated to be areas, such as Southend, Kintyre (Boyd Watt), which it has not yet reached.

Wherever the soil permits or earth-worms are found, it ascends to the summits of the highest hills, as in Yorkshire (Roberts, *Zoologist*, 1872, 3182-3183). It has been observed at altitudes of 1700 feet, or practically the highest point, on the Pentlands, and even higher on the Ochils (W. Evans), while in the Solway and

Clyde areas, and in Wales, it has been detected by Service, Boyd Watt, and Forrest at 2000 feet at least in each case, the first observer recording its presence at 2782 feet on the Merrick (*Trans. Edinburgh Field Naturalists' and Microscopical Society*, vi., i., 64, 1907-8). Boyd Watt has found it at 1200 feet, when the snow-line was 200 feet below. For the Tay area it has been recorded from 1500 feet (Godfrey in Harvie-Brown), and its workings occur at well over 2000 feet on the Loch Tay hills (Evans *in lit.*). On the other hand, its burrows may be found in the sand-dunes by the sea beach, as at Thurso, Caithness (Kinnear), at North Berwick, Haddington (Evans), and elsewhere; at Malldraeth and elsewhere in Anglesey it even frequents ground flooded by spring tides (Oldham in MS.; see also Forrest).

From the islands it is as a rule absent, but occurs in Jersey (Bunting, *Zoologist*, 1908, 461) and Alderney (Eagle Clarke); is common in Wight (More; Bury; Wadham); and numerous in Anglesey (Coward). In the Clyde Isles and Inner Hebrides it is known only from Bute, whence Pennant reported it in 1777 (see also W. Evans, *Ann. Scott. Nat. Hist.*, 1905, 241); Ulva, off Mull, where it is stated to have first appeared in February 1892 (Harvie-Brown and Buckley); and Mull, where it is numerous and its presence is locally attributed to a legendary introduction in a boatload of earth sent from Morven early in the eighteenth century (Alston). Remains found on Ailsa Craig were probably carried there by predatory birds (Boyd Watt).

Despite its absence from the Shetlands, Orkneys, Outer Hebrides, Man, and **Ireland**,[1] it is known by a Gaelic name to the inhabitants of the two latter islands.

Distribution in time:—A species from the Cromer Forest Bed (late Pliocene) hitherto referred to *T. europæa*, in reality belongs to another and extinct species. The fossil remains which are found in British late Pleistocene deposits, such as the Ightham Fissures in Kent and the Teesdale caves in Yorkshire, represent a form much more closely related to the living *T. europæa* than the older Forest Bed species.

The **rutting season** is normally confined to the end of March, April, and, occasionally, part of May. The **period of gestation** is about four weeks, or slightly more. The **young**, averaging between three and four, with extremes of one and seven, are born normally from about the 24th April to the middle of June. Occasionally late litters have been observed in August or September, but there is no evidence that the Mole breeds twice a year (Adams, *Mem. and Proc. Manchester Lit. and Philosoph. Soc.*, xlvii., No. 4, 23, read 18th Nov. 1902 (1903)).

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[1] A bird's "pellet" picked up in Benevenagh Woods, Bellarena, Co. Londonderry, by R. Welch, was found by Adams to contain the skull of a mole, perhaps brought over by a hawk from Scotland (*Irish Naturalist*, 1905, 72).

Description:—The general form and appearance of the Common Mole are typical of its genus.

The **eye** is set low down and far forward. The small eyeball has a diameter of about 1 m.; the irides are dark brown, the pupil circular (see Davy, *Proc. Zool. Soc.* (London), 1851, 129-131). The eye is relatively more prominent in the fœtus (Geoffroy, also Bruton, *Manchester Mem. cit. supra*, xlviii., 1904, No. 20). There is neither orbit nor eyelash, and the small external aperture, about 1 m. in diameter, can only doubtfully be said to possess an eyelid. The ear is without any external conch. The fingers are short, with all the phalanges about equal in size.

The very soft, short, silky **fur** covers the whole body down to the feet and hands, but on the scaly tail is reduced to a few long stiff hairs. It shines like iridescent velvet, so that the **colour**, which at the first impression appears to be pure black, varies according to the direction from which it is viewed; it is bright grey when seen in the direction in which the hairs lie, and rich deep black from the opposite point of view; a slight yellowish tinge appears on the lower jaw and along the middle of the belly. There is much individual variation, both as to general colour and amongst the individual hairs, which may have the tips and bases of different shades.

Little is known as regards **seasonal variation** or **moult**; the latter takes place, perhaps as in the shrews, twice a year, namely, in spring and autumn. Service (*Trans. Edinburgh Field Naturalists' and Microscopical Society*, vi., i., 64, 1907-8) states that the winter coat is changed immediately after the breeding season, the male preceding the female by several weeks, but both sexes have usually assumed their new coat by the first week of June. Adams's observation of a mole shedding its coat in May (*in lit.*) is corroboratory.

The **young** at birth are pink and hairless, but as they increase in size the skin grows darker, assuming a dark slate-blue colour before the fur begins to appear (see also p. 12).

The number of **mammæ** is probably variable. The most usual number is believed to be six, but Adams (*op. cit.*, Fig. 28) has figured a specimen having eight, placed in pairs along the entire pectoral and inguinal surface. They are not readily seen even when the female has young.

Genital organs:—Without dissection it is difficult to distinguish the sex of immature animals. Until the first breeding season, the vagina is imperforate and the clitoris closely resembles a penis.

At the end of January the uterus and vagina of the female, and the testes, prostate, and corpus spongiosum of the male undergo considerable enlargement, attaining a maximum at about the end of March or beginning of April, when pairing takes place. After this date the organs decrease, and by the end of May have returned to their minimum size, which they retain for the rest of the year (Adams, *op. cit.*).

The **skull** and **teeth** are typical of the genus.

Individual colour variation is very frequent. The most usual types may be arranged in three classes, viz., (1) true pink-eyed albinos; (2) those with yellow or whitish markings; (3) ashy or silver grey.

Class 1—Absolutely white specimens with pink eyes are almost or quite unknown, but there are on record a cream-coloured one from near Eton (Clark-Kennedy, *Zoologist*, 1867, 702) and an "orange-pink" male, with dusky shading on the back, from Somerset (Garnett, *Field*, 21st June 1902, 978), each with pink eyes.

Class 2 includes numerous individuals displaying almost every form of gradation from wholly whitish, but not absolutely white, to normal, with orange, yellowish, or whitish markings. These markings most usually take the form of a patch or streak on the throat or abdomen, and in such cases there are usually a few whitish hairs on the feet and tail (see Service's figures, *Ann. Scott. Nat. Hist.*, 1903, pl. i.). In many of the wholly cream-coloured forms, the throat and under side are more or less completely tinted with rich orange and ferruginous hues, which may extend to the limbs, cheeks, nape, or dorsal line (Southwell, *Zoologist*, 1888, 22). Variations of the above type are so numerous that they can hardly be styled abnormal. They are often confined to definite areas (Service; see also Perkins, *Field*, 10th April 1909, 641), and in some localities, as near Oby and Clippesby in Norfolk (Southwell, *Trans. Norfolk and Norwich Nat. Soc.*, iii., 25th March 1884, 667), and on Gullane Links, Haddington (W. Evans, *in lit.*), they are common, and appear to be restricted to certain families, in which all the young of a litter may be affected.

In some cases associated with the above type the tips of the hairs remain of a dusky colour, although the bases are light (Aplin, *Zoologist*, 1882, 351). In a female described by Service (*Ann. Scott. Nat. Hist.*, 1904, 66), the general colour was glossy slate-black, with suggestions of plum-blue on the upper side; the light hair-bases were restricted to the under side. In another example, sent for examination by Forrest, all the hairs were bicoloured, with the bases on the right side only of the body tinted with orange; the central abdominal region, a throat-patch, and a band running across the head between the eyes and snout, were also orange.

Pied or skewbald varieties, other than as described above, are quite rare; one is stated to have had two white spots on the back, the white hairs being of unusual length (Ford, *Zoologist*, 1882, 263); as was also the case with one from Bristol (Charbonnier); others were cream or orange coloured, mottled or striped with black (Cordeaux, *Zoologist*, 1868, 1186; Prior, *Journ. cit.*, 1877, 225-226); one had a white head (W. Evans); in another the nose and tail were tipped with white, and there was a white breast-spot (Forrest); while J. Whitaker has figured one which was largely cream colour with dark underside and head, the lines of demarcation being of irregular course (*Scribblings of a Hedgerow Naturalist*, 1904, 238).

Class 3—Ash, or mouse-coloured, silvery-grey, and bluish-lead specimens are occasionally met with, but are not common (see Tomes, *Vict. Co. Hist.*, Worcestershire, 174; Larken, *Zoologist*, 1890, 97-98; Crewe, *Field*, 25th February 1893, 296; Service, *Ann. Scott. Nat. Hist.*, 1908, 117). Adams writes me that he possesses an ash-coloured specimen caught at Penistone, Yorkshire, and W. Evans reports a fawn-coloured one taken at Gullane, Haddington, in November 1910, also a beautiful silvery-grey variety taken near Edinburgh in February 1911 (*in lit.*).

The sex of animals varying in colour is seldom given by recorders, and even when stated is not always reliable, field naturalists being frequently in error in judging the sex of moles. Service, however, states that in cream-coloured specimens the female is always lighter than the male (*Zoologist*, 1893, 425). This writer's articles on variation may be consulted for further information, as may be Harting, *Field*, 19th July 1902, 141.

The Common Mole seems to be very free from **geographical variation**, but Matschie (*Sitzungs-Berichte der Gesellschaft Naturforschender Freunde* (Berlin), 1901, 9, 229) suggests that the Roumanian form differs from that of central Germany; and Rollinat and Trouessart (*Comptes rendus Soc. Biol.* (Paris), 15th December 1906, 602) state that in France, towards the southern limit of its range, the degree of development of the eye is variable, and that frequently no external eye is visible. They conclude that the disappearance of the eyes has taken place recently, and that it is connected with the stronger light of the south. Satunin has described a subspecies, *T. e. brauneri*, from south Russia, but I have not been able to examine it.

William Evans believes that individuals inhabiting the upland districts of the Edinburgh district are on the average rather larger than those of the lowlands.

DIMENSIONS IN MILLIMETRES.

Ten specimens in British Museum.	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).
Maximum . . .	147	32	21
Average . . .	139	27·7	19·2
Minimum . . .	122	20	16

The above dimensions are taken from the labels, and rest on the authority of the various collectors. The sex of the specimens has not been given here, as such determinations are frequently unreliable. Service (*Trans. Edinburgh Field Naturalists' and Microscopical Society*, vi., i., 64, 1907-8) states that males are larger than females, the maximum total length known to him for each sex being about 195 and 156 respectively, but these figures were quite exceptional, and the average for females would be about 140. Adams also finds males larger; adults measured by him have had the head and body varying between 140 and 127, while young in the nest have reached 118. Three females averaged for head and body 133, tail 33, and hind foot 20.

The table following, for which I am indebted to Adams, indicates the rate of growth of young examined in the nest from the first to the twenty-second day after birth (see also *Mem. and Proc. Manchester Lit. and Philosoph. Soc.*, liv., 2, 9, 1909):—

Number of days old.	Head and body.	Tail.	Hind foot.	Colour.	Remarks.
1	42	8	5	Very red . . .	Umbilical cord unhealed.
2	47	9	5·5	Red . . .	Do.
5	62	10	8	Pink.	..
7	70 71	12 15	9 9	Pink.	..
9	80	15	11	Slightly lead coloured on back only.	
11	88 91	16 17	12 13	Lead coloured above, lower parts pink.	..
12	95	16	14	Do.	..
14	105	17	16	Lead coloured all over; fur just visible.	..
17	114	23	16	Completely clothed with velvety, lead-coloured fur	Ears open.
21	117	25	17	Fur approaching normal colour and length	Eyes showing spot of matter, but not yet open.
22	118	27	16·5	Fur almost normal . .	Eyes opening.

Skull:—Condylar basal length, 34 to 36; greatest breadth at zygoma, 12 to 13; greatest breadth of brain-case, 14·8 to 17·8; greatest interorbital breadth, 8·2 to 8·8; breadth of rostrum over canines, 4·8 to 5; depth of brain-case through bulla, 10·2 to 10·6; length of mandible, 22 to 23·4; length of upper tooth-row, excluding incisors, 12·8 to 13·4; length of entire lower tooth-row (alveolar), 13 to 13·2.

Weights:—Eagle Clarke sends me the following weights in grammes of thirteen Scottish specimens taken near Edinburgh:—81·6 (19th September); 74·5 (3rd October); 121·5, 112·7, 110·8, 101·7, 95·2, 91, 88·5, 86, 82·2, 77·5, 68·5 (9th November). Several were no doubt immature, but, since 100 grammes = 3·6 oz., the larger measurements agree with Aflalo's statement that the average weight of adults is just under 4 oz. One weighed by Kinnear reached 80·64 grammes.

Few of our native mammals have supplied more material for fancy writing to authors of works on natural history than the subject of this article, many pages of imaginative admiration having been devoted to it. Difficulties of observation have no doubt much to do with this. At any rate, paragraphs are published expressing commiseration with the poor creature's life of incessant toil in subterranean darkness, and rapture at its form and the peculiarities of its structure. Surprise is expressed at its wonderful adaptation to its mode of life, and minute descriptions are added of the well-nigh mathematical plans upon which its under-ground home and habitations are supposed to be constructed.

Amongst so much fiction,[1] to which authorities of such weight as Blasius, MacGillivray, and Bell contributed each their quotum, it is difficult to find the truth. Indeed, were it not for the recent studies of Messrs William Evans[2] and Lionel E. Adams,[3] the compiler's task would have been most unenviable. Few accurate observations were previously on record. Gilbert White almost ignored the animal, and other early writers were unacquainted with its habits.

For the first detailed account of the life of the Mole, we are indebted to Henri le Court, who originally held a lucrative situation at the French Court, but retired from the horrors of the Revolution into the country, to devote himself to the study of this animal and of the most efficient means for its extirpation. Le Court imparted his knowledge to his friend and pupil Antoine Alexis Cadet de Vaux, who published a small book on the subject in 1803.[4] Mr Adams thinks that this interesting work is on the whole a trustworthy record of Le Court's observations, although here and there the writer has allowed considerable play to his imagination.

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[1] A paper in the *Field* of 11th July 1908, 90-91, wherein Colonel R. F. Meysey-Thompson quotes largely from a mole-catcher, is a good example of the prevailing intermixture of correct and incorrect observations.

[2] First published in 1892 in *Proc. Roy. Phys. Soc.*, Edinburgh, Sess. xi., 1890-1891, 85-171, read 15th April 1891. I am also indebted to Evans for many unpublished original observations of which I have made free use.

[3] "A Contribution to our Knowledge of the Mole (*Talpa europæa*)," *Mem. and Proc. Manchester Lit. and Philosoph. Soc.*, xlvii., 4, 1-39, read 18th November 1902 (1903); "Observations on a Captive Mole (*Talpa europæa*)," *Journ. cit.*, l., 9, 1-7, read 10th April 1906 (1906); also, "Some Notes on the Breeding Habits of the Common Mole," *Journ. cit.*, liv., 2, 1-9, and plate, read 19th October 1909 (1909). Adams has also favoured me with his note-books containing many supplementary observations of great value and interest, the whole of which he has placed at my disposal, and has, besides, rendered assistance by reading the MS. of this article.

[4] *De la Taupe, de ses mœurs, deses habitudes, et des moyens de la détruire* (Paris, 1803).

Le Court's studies attracted the attention of the celebrated naturalist Étienne Geoffroy, who visited him for the purpose of ascertaining the truth and extent of his discoveries, and subsequently copied most of de Vaux's essay for his own work, published in 1829.[1] Geoffroy's account of the animal may be divided into two parts, in one of which he reproduced de Vaux; in the other he published the results of his own anatomical studies. The former, in which the imaginative parts unfortunately occupy a prominent position, has been the happy hunting-ground of most subsequent writers; the latter, although interesting and valuable, has been frequently ignored. Verification of de Vaux's statements has been but seldom attempted, but Bingley's account of the animal may be mentioned as still readable and instructive. An extraordinary and amusing, but original, treatise is that of the Rev. James Grierson, who, writing in 1821 to 1822, transcribed the information imparted to him by a mole-catcher.[2]

A great many of the myths surrounding the natural history of the Mole were exploded by Mr Adams's classical paper, the results of four years' study in the neighbourhood of Stafford. This paper will no doubt for long form the model of future accounts of the animal.

The Mole is essentially a burrowing animal, spending nearly all its time under-ground, and feeding, almost but not exclusively, on the earthworms which it meets in its tunnelling. It follows that its form and limbs are highly specialised for the fulfilment of a peculiar existence, from the ordinary routine of which there is but little variation, and which is accompanied by curious and interesting instincts.

The general form of the body is calculated to facilitate its rapid progress through the subterranean passages which form its habitual routes between the different parts of its domain.

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[1] *Cours de l'Histoire Naturelle des Mammifères* (Paris, 1829).

[2] "Some Observations on the Natural History and Habits of the Mole," by the Rev. James Grierson, M.D., M.W.S., Minister of Cockpen, in *Mem. Wernerian Soc.*, IV., i., 218-236, 1821-22.

The anterior extremities are admirably constructed for the purpose of progression through the soil, while the hind legs are employed in such acts of running or walking as are inseparable even from a miner's existence. The snout is a very important organ, being employed either in acts of prehension, or as the sensitive guide to assist the hands when boring; it is also the seat of what is probably the most highly developed sense the Mole possesses, that of smell. The sense of sight, so important to most animals, would in the present case be useless, at least during by far the greater portion of its existence; and hence we find that it is reduced to its minimum of development, and sacrificed, as it were, to the necessary pre-eminence of that of smell. There can, indeed, be no doubt that to the latter sense the Mole is indebted for the perception of its food, of its enemies, and of its mate; indeed, Mr J. L. Bonhote informs me that a captive in his possession could always detect worms placed at the other side of a wooden partition in its box. At the same time, it appears to be much assisted by the sense of hearing, which, although without the usual aid of an external conch, is certainly very acute. Shakespeare was not unmindful of this fact:—

> "Pray you, tread softly, that the blind mole may not
> Hear a footfall:"
>
> —*The Tempest*, IV., 1, 194.

The interesting question whether the Common Mole possesses true vision, has long been discussed amongst naturalists, whose opinions have no doubt been at times confused by the existence of more than one European species of the genus. The eyes of Savi's Mole,[1] which replaces our own in parts of the south of Europe, have no external opening, a fact which is probably responsible for Aristotle's declaration that the Mole is absolutely blind. The eyes of the Common Mole are, however, at least in England, provided with an aperture admitting the entrance of light, and the actual eyeballs and lenses, although very small, are both present and capable of use. This was shown long ago by Geoffroy, and more recently by

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[1] *T. cæca*, Savi.

Herr Carl Hess[1] of Germany. The latter denies that the animal is even short-sighted.

But, even allowing so much, it was conceded by Herr Hess that while under-ground the eyes must be quite useless. It is evident that their low forward position in a head, the aspect of which is downwards, not to mention the thick fur surrounding them, and the grass amongst which the animal usually moves when above ground, must combine to restrict the vision, even of acute eyes, to a radius of a few inches. This is entirely borne out by the observations of practical naturalists like E. R. Alston,[2] Dr H. Laver,[3] and Mr Adams, who, although admitting that the eyes appear functional, find from careful observation that they are of little or no service to the animal. Mr Adams is thoroughly convinced that the Mole is practically blind. A captive individual, when confronted with a worm, immediately perceives its proximity and shows signs of excitement. But it invariably has to search for it; and the random way in which it does so until it strikes the worm haphazard, suggests a probable absence of sight. So much was this the case, indeed, with one kept captive by Alston, which "puzzled round" a piece of meat so long before finding it, that he was inclined to disparage its sense of smell also. Although a very slight movement is at once perceived, probably by the sense of hearing, a mole proved absolutely indifferent to the presence of a lighted candle, even when waved about before its face, and would have actually run into the flame if permitted to do so. Mr Adams argues that the animal could hardly be indifferent to such a startling and unfamiliar phenomenon close in front of its eyes, unless the light were imperceptible.[4]

It is probable that the whole controversy has arisen out of an existing variability in the eyesight of individuals. For instance, Messrs R. Rollinat and E. L. Trouessart find that towards the southern extremity of the Mole's range in France the eyes are not infrequently concealed beneath the skin, and the conflicting reports are very easily intelligible if it is supposed that this variability extends to other districts.

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[1] *Nature*, xli., 1889-90, 373, transcribed in *Zoologist*, 1890, 98; see also John Davy, *Proc. Zool. Soc.* (London), 1851, 129. [2] *Zoologist*, 1865, 9707. [3] *In lit.*

[4] But it should be noted that many wild or inexperienced domestic animals apparently take no notice of a light or a fire until they approach near enough to feel the heat. A. H. Cocks finds also that the sense of smell is not normal in animals confined in boxes or cages.

A curious, but true, old story, that the fur around the eyes is sometimes radiated, has been mentioned by many authors, and dates at least from the latter half of the fifteenth century, when Bartholomæus Anglicus[1] wrote: "And some men trow that the skin of the mole breaketh for anguish and sorrow when he beginneth to die, and beginneth then to open the eyes in dying that were closed living." This has been observed by Mr Adams during the spasms of a dying mole, as well as frequently by Dr Laver.[2] Mr F. A. Bruton[3] has noticed that a distinct conical cavity may be formed by radiation of the fur, at the bottom of which the black circular eye was clearly seen by him with no protection whatever.

Everyone has seen on the surface of the ground the evidences of the Mole's burrowing for its food; they are indeed plain almost everywhere in Great Britain, from the sand-dunes and salt-marshes of the sea-shore to the upland pastures and the higher slopes of the mountains. The plan upon which it works has, however, formed the subject of some discussion; by most writers the animal has been endowed with a knowledge of architectural symmetry in the scheme of its tunnels, characteristic rather of an engineer than of a wild animal. The usual idea of the domain, district, or encampment, as it is variously called, is somewhat as shown in Fig. 1, each animal being supposed to confine itself to the actual limits or immediate neighbourhood of its own district. But this cannot really be the case, since a trap placed in a run may catch many more than one. Possibly the truth is that the old males, as in the case of so many other mammals, are more or less solitary, the females and young comparatively sociable.

There is a central habitation or fortress, from which extends a main tunnel or high-road, by which it is supposed that the animal reaches the extremities of its domain, and from which open out numerous minor galleries or excavations. These are the hunting-grounds of the males, and are being continually extended in their search for food. This description, strange to say, does not apply to the females, which dig their runs in all directions, so as to form no recognisable high-road. This fact was discovered by le Court and verified by Mr Adams. In both types, there are sometimes to be found certain partially or completely open surface-furrows, which are usually known as "coupling runs," "rutting angles,"[1] or *traces d'amour*. These

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[1] *De Proprietatibus Rerum*, lib. 18, cap. 100, fol. 1471, English version, 1535.

[2] *In lit.*

[3] *Op. cit. supra*, p. 9.

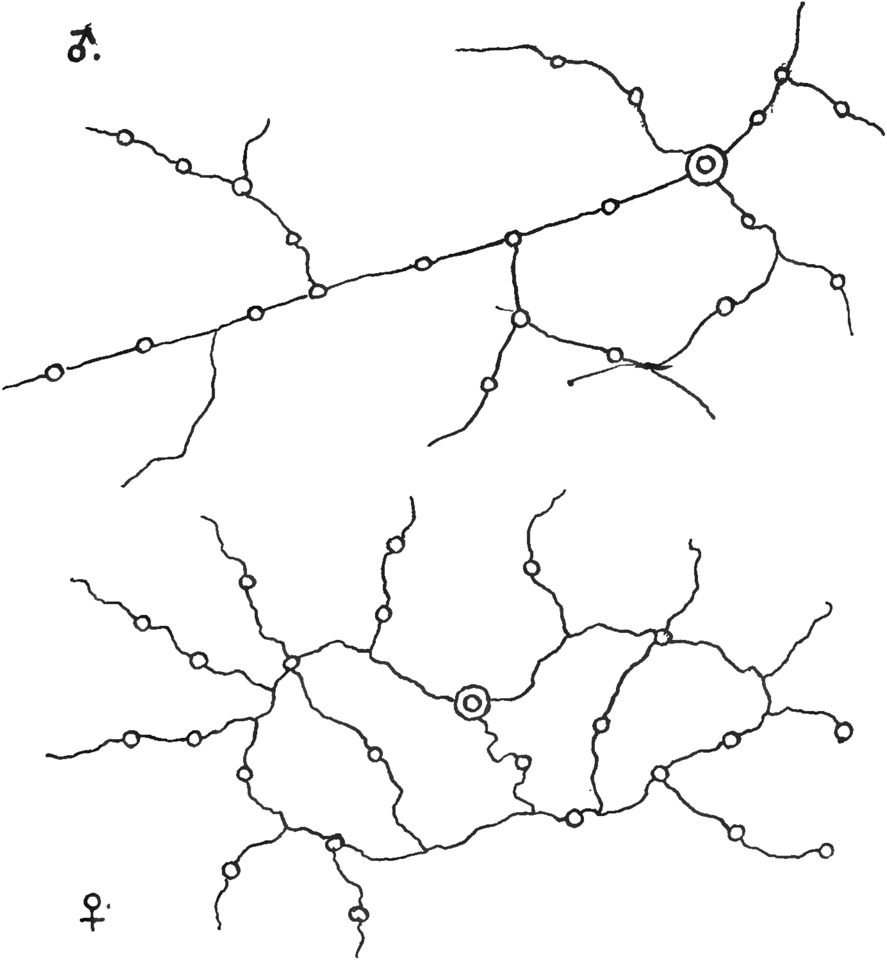

Fig. 2.—Encampment of Mole. ♂ male, ♀ female, ◎ fortress, 〰 tunnels, O outlets for earth (diagrammatic, after Adams).

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[1] Angle, a name given to the holes or runs of animals, such as badgers or field-mice, and in some places to artificial burrows used for capturing rabbits in warrens, is not connected with "angle," a worm for fishing, or "angle-dog," a Devonshire name for an earthworm (*see* Wright).

are more frequently met with during the pairing season than at other times, but on damp soft land they may occasionally be seen at any time of the year. They may be straight and long (as if the work of a male), having been measured by Mr Adams up to a length of one hundred yards; or much shorter, reaching fifteen to twenty yards only, and tortuous or meandering (suggestive of a female). They are probably the work of an animal changing its district, but whether of an individual in search of a mate or otherwise, has not been determined.

The structure of the fortress was long supposed to be based on an unvarying plan of remarkable symmetry, and most text-books complacently reproduce, apparently without attempt at verification, a stereotyped figure which owes its origin to Geoffroy, with elaborations by Blasius. This figure is largely imaginative, and differs from that presented by de Vaux, evidently as the result of an actual dissection; nevertheless it seems to have met with universal acceptance until Captain Mayne Reid questioned its accuracy.[1] In 1891, Mr Evans, after frequent excavations of "hillocks" in Scotland, confessed his inability to harmonise them with the accepted diagram, and figured the plan of one differing markedly therefrom. Occasionally a close agreement may be observed; but as a rule the departure from the stereotyped form is considerable, a conclusion completely substantiated by that of Mr Adams, formed eleven years later, after carefully drawing numerous fortresses.

Mr Adams's plans show that sometimes the fortresses are extremely complicated and sometimes very simple, but in no case are they, as suggested by the books, built on a prearranged system of labyrinthine escapes from enemies above and below. On the contrary, the galleries are rather the natural, incidental, and inevitable outcome of the work of excavating the nest-cavity and piling up the superincumbent mound.

"The site for the fortress having been determined," writes this author, "a circular cavity as a receptacle for the nest is made from two to six inches below the original surface of the ground, except in boggy soil or low-lying land liable to floods, where

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[1] *The Naturalist in Siluria*, 124, 1889, wherein are also some other interesting remarks on the Mole, which I should have quoted had I been able to secure a copy earlier.

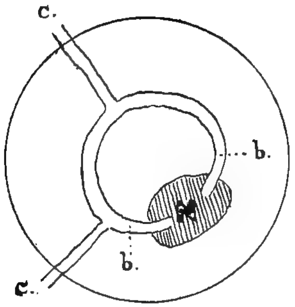

FIG. 3.—PLAN OF TUNNELS OF SIMPLE FORTRESS. See also Fig. 4.

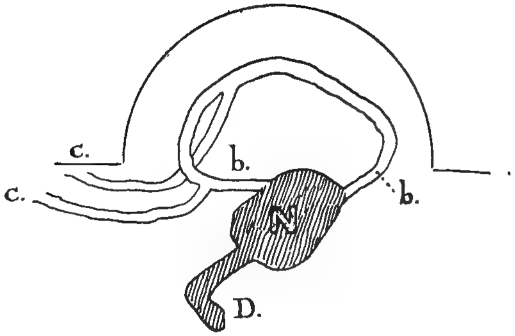

FIG. 4.—SECTION OF SIMPLE FORTRESS, plan of which is shown in Fig. 3.

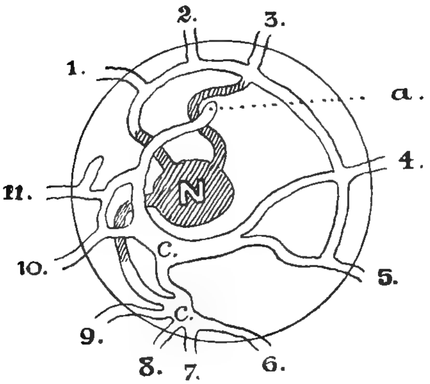
2.
3.
1.
a.
4.
11.
N
c.
10.
5.
c.
9.
8.
7.
6.

FIG. 5.—PLAN OF COMPLICATED FORTRESS, WITH ELEVEN EXITS.

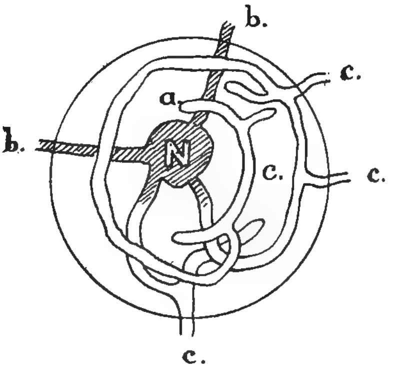

FIG. 6.—PLAN OF COMPLICATED FORTRESS, WITH SEVERAL BLIND TERMINALS. See also Fig. 12.

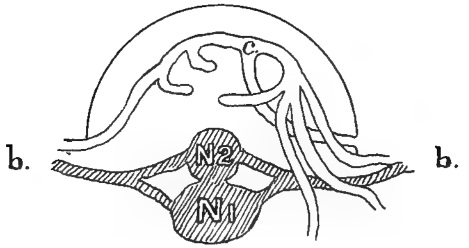

FIG. 7.—SECTION OF FORTRESS ON MARSHY GROUND, WITH OLD (N1) AND NEW (N2) NESTS. See also Fig. 8.

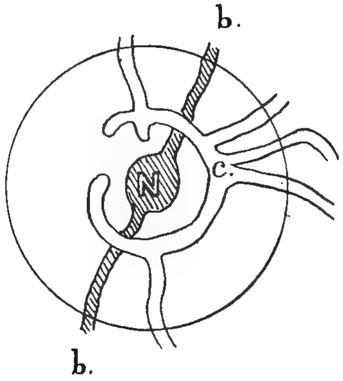

FIG. 8.—PLAN OF FORTRESS SHOWN IN FIG. 7.

the nest is often above the ground-level in the centre of a heap of earth which is thrown up from converging runs (Figs. 7, 8, and 9).[1] Now, the easiest way to dispose of the earth when the nest-cavity is being excavated is to push it upwards on to

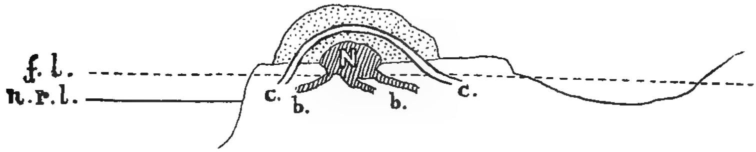

FIG. 9.—SECTION OF NEST ABOVE GROUND-LEVEL IN LAND LIABLE TO BE FLOODED.

the surface, and in order to do this a tunnel must be made. Fig. 10 shows the whole heap made entirely by this tunnel. Fig. 11 illustrates a low fortress on boggy ground, the whole heap being formed by a single tunnel (*a*) leading upwards from the nest. This nest had seven outlets just below the soil. There was no other tunnel or bolt-run."

"When this superincumbent earth has reached an inconvenient height another tunnel is made, sometimes from another part of the nest-cavity (Figs. 3, 4 *b*, *b*), but more often sideways from the first upward tunnel." Meanwhile the Mole is constantly making fresh runs from the fortress in various directions in search of food. As these fresh runs grow in length, the task of piling up the protective mound is lightened by the excavations of new tunnels from runs near the edge of the fortress, which usually lie above those leading from the nest-cavity.

The tunnels in the fortress serve two distinct purposes:—

(*a*) To eject earth from the nest-cavity and bolt-run.

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[1] KEY TO LETTERING ON 18 DIAGRAMS OF MOLE EXCAVATIONS.

The same letters apply to all.

a. = Apex of tunnels.
b. = Bolt-runs, or tunnels made in excavating nest.
c. = Tunnels made in forming protective heap, and their outlets.
D. = Downshaft.
f.e. = Flood exit.
f.l. = Flood level.
n.r.l. = Normal river level.
l.c.g. = Lower circular gallery.
u.c.g. = Upper circular gallery.
T. = Turf.
N. = Nest.
N1, N2, N3 = First, second, and third nests.
o.o. = Original outline of fortress.
o.t. = Original tunnel formed by heaping up the fortress.

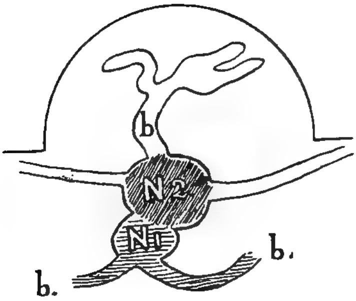


FIG. 10.—SECTION OF FORTRESS, with heap made entirely of earth excavated from nest, and pushed upwards through one tunnel. There are two bolt-runs.

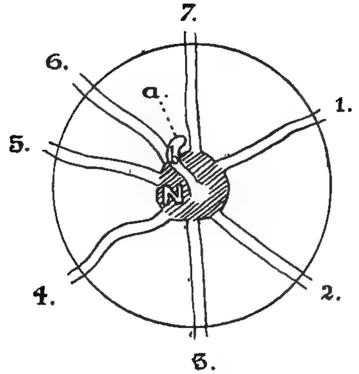


FIG. 11.—PLAN OF LOW-LYING FORTRESS ON BOGGY GROUND, the whole heap formed by a single tunnel (*a*) leading upwards from the nest. There are seven direct outlets from the nest.

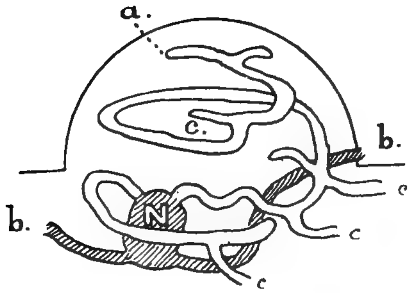


FIG. 12.—SECTION OF FORTRESS SHOWN IN FIG. 6, showing spiral gallery and blind terminals.

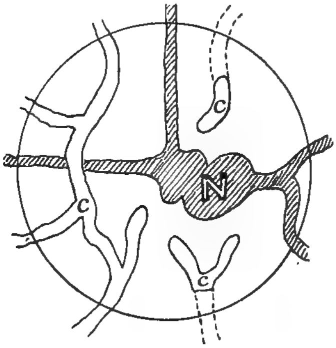


FIG. 13.—PLAN OF FORTRESS, showing portions of tunnels which subsequently fell in, and their probable course :::::

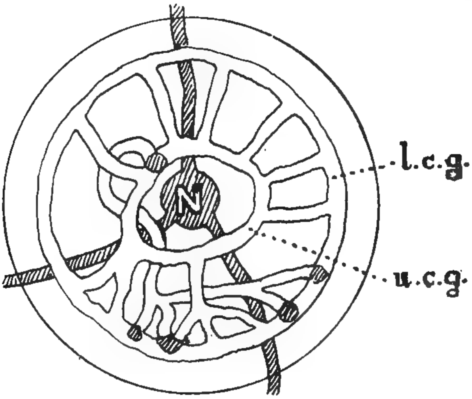
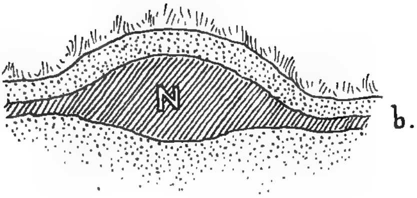


FIG. 14.—PLAN OF UNUSUAL FORTRESS WITH BOTH UPPER AND LOWER CIRCULAR GALLERIES.



IG. 15.—SECTION OF BREEDING NEST, lying st below slightly upraised and unbroken turf.

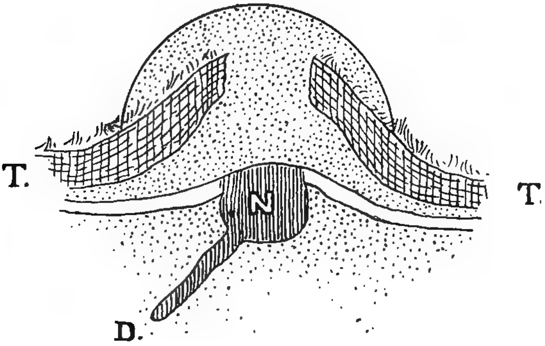
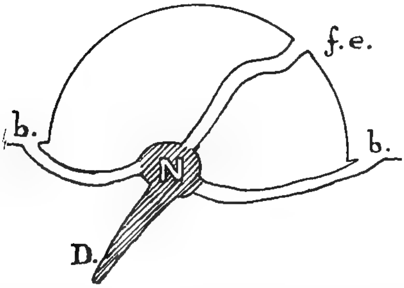


FIG. 16.—SECTION OF NEST UNDER MOUND IN BROKEN TURF IN PEATY LAND.



17.—SECTION OF NEST IN MARSHY LAND. e down-shaft D, measuring eighteen inches length from bottom of nest, was full of water en found ; *f.e.* was probably a flood exit.

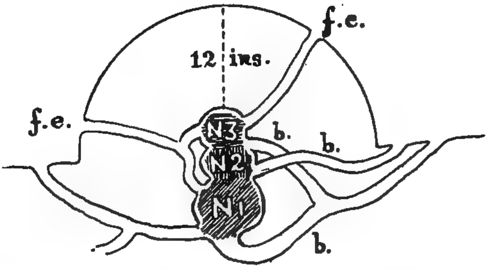
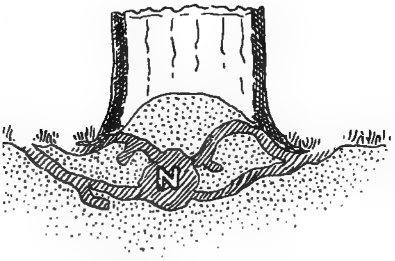


FIG. 18.—SECTION OF FORTRESS WITH THREE NESTS, the new one (N3) built on top of the others.



. 19.—SECTION OF FORTRESS IN OLD TREE-TRUNK.

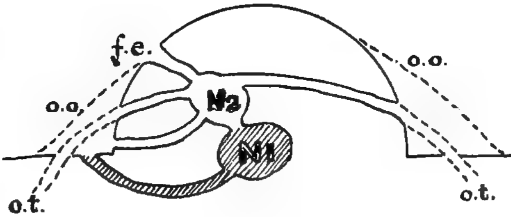


FIG. 20.—SECTION OF FORTRESS IN LOW BOGGY LAND.

These are generally in ascending spirals, and often terminate blindly (Fig. 12).

(*b*) Those not connected directly with the nest-cavity, but traversing the fortress from runs outside it. Through these earth has been carried to form a protective heap over the nest. Fig. 14 represents a rare case of the spiral tunnel assuming the stereotyped form of upper and lower "circular galleries," as represented by de Vaux and others.

The so-called "lower circular gallery" is formed, according to Mr Adams's explanation, when the many tunnels and up-shafts become connected at their bases during the heaving-up of turf. In peaty or marshy grounds large pieces of turf are often raised, and beneath such an upheaval Mr Adams has found a nest containing young.

The average fortress is about one foot in height and three feet in diameter, but Mr Adams has measured one fifteen inches in height and five feet in diameter. Mr Evans examined another, the diameter of which reached no less than eight and the height nearly two and a half feet.

The nest-cavity is roughly spherical, about the size of a large cottage loaf, and quite smooth from constant friction and use. The nest, which completely fills the nest-cavity, is a ball of grass, or leaves and moss,[1] or a mixture of all three. Mr Adams found a nest made entirely of dead beech leaves, others entirely of dead oak leaves. In a nest made of grass the finest and driest material is in the centre, the coarsest outside and mixed with damp earth. Usually, if taken out bodily, the nest must be unwound to find the centre, but on land where the grass is short it comes to pieces very easily. There is never a hole apparent, and not only is the nest always found closed when the young are within, but in all cases, even when old and long deserted. When dry grass is not obtainable fresh green grass is used, which soon withers and gets dry with the heat of the mole's body. The inside of the nest is warm to the touch when the animal has not long quitted it. Nests containing young, as well as those of the males found in their fortresses, are invariably infested with fleas and mites.

Despite le Court's contrary assertions, Mr Adams has in

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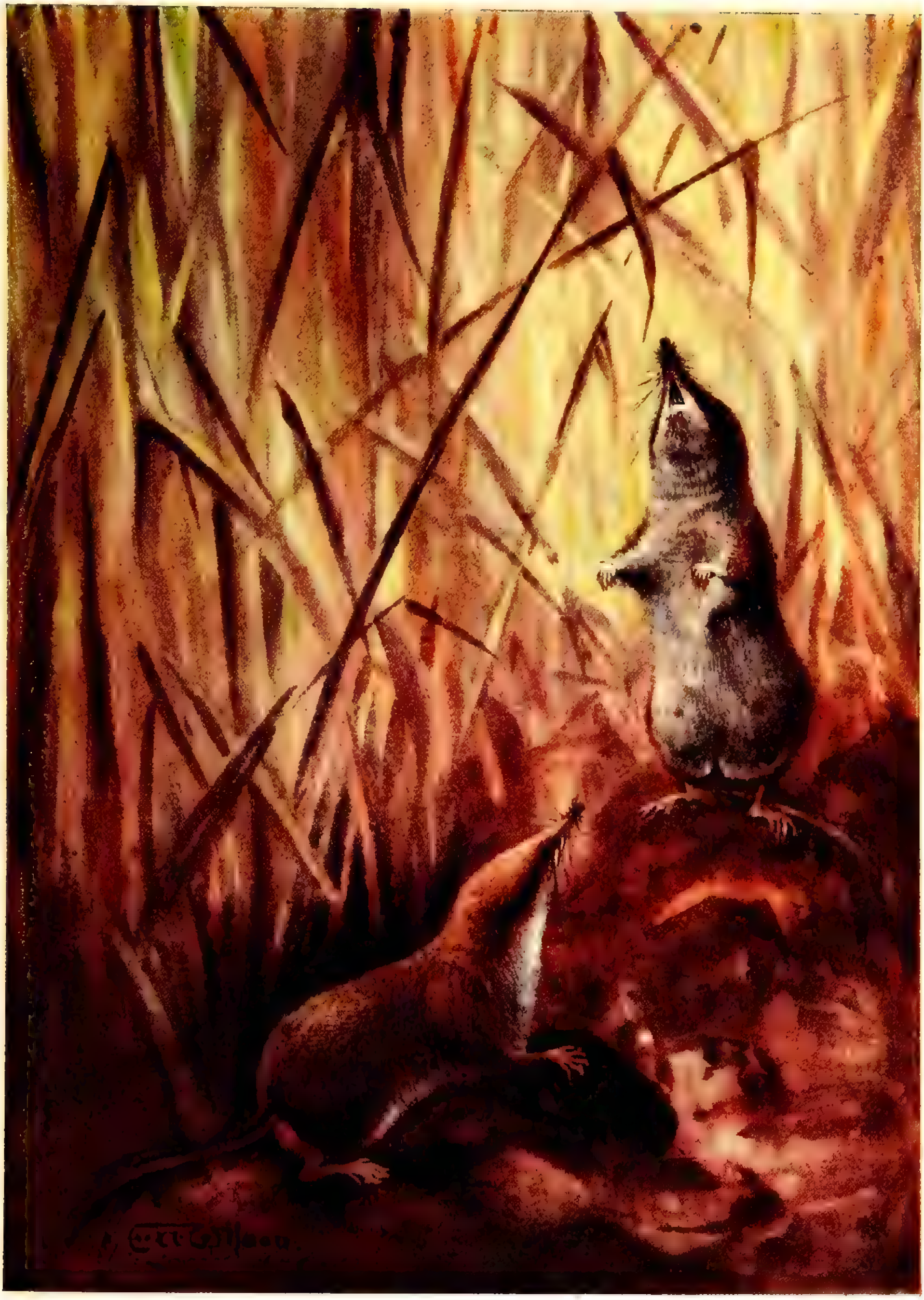
[1] This paragraph, *fide* Adams and Evans.



Pygmy or Lesser Shrews.

only one instance found a nest in which the component materials were mixed with fur taken from the Mole's own body.[1] He believes that the presence of the fur was accidental, and due to natural moulting of the coat. Sometimes the fur of other animals, or the feathers of birds, especially rooks and fowls, find their way[2] into the nest, but it is difficult to decide whether fur or feathers are used knowingly or merely by chance.[3]

"Nearly every fortress has a bolt-run, by which the mole can escape when surprised in the nest. This run leads downwards from the bottom of the nest, and then turns upward and out of the fortress by a tunnel of its own, and is very rarely connected with any of the other numerous exits of the fortress. The only fortresses that I have seen without the bolt-run have been on marshy land, where such a tunnel would have led to water."[4] (See Figs. 9 and 15.)

"Occasionally one comes upon a downshaft, leading directly from the nest downwards almost perpendicularly for sometimes nearly three feet. The use of these downshafts is puzzling. Where the land is low-lying and the soil moist they may be intended to drain the nest, but this is inconceivable in the Bunter sandstone on high ground above the level of the highest floods, where I have found them on more than one occasion. It has been stated that they are deliberately sunk as wells to supply the mole with water, a notion which, I imagine, has arisen from a flooded fortress having been explored. Figs. 4, 16, and 17 illustrate such fortresses, which came under my notice, but it is ridiculous to suppose that the mole foresees the possible rise of water from below, and equally ridiculous to suppose that he digs the well through the water when it has risen."

Mr Adams makes the suggestion that these downshafts are abortive bolt-runs, which have been abandoned when it was found that the right point to turn upwards had been missed, a suggestion which he thinks gains probability from the fact that when the downshafts occur the bolt-run is absent.

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[1] This nest was forwarded for my inspection, but, unfortunately, never reached me.

[2] As reported by W. H. St Quintin, *Field*, 31st March 1883, 431, a nest contained, besides moss and dried grass, two handfuls of fur and the mutilated body of a recently killed mouse (*Microtus agrestis*).

[3] For a description of the actions of a mole when collecting leaves for its nest, see note on p. 43 *infra*.

[4] Adams.

It appears that a nest is never resorted to in a second year, but a fresh one is made each year close to the same spot. Thus two or three nests, only one of which is as a rule fresh and inhabited, are frequently found in close conjunction. The new nests are often built on top of the others, and are constructed of fresh material brought in from outside (Figs. 7, 10, 18, 20). Two inhabited nests are very rarely encountered in contiguity, and the most conspicuous instances known to Mr Adams have been those of breeding females.

In its choice of a site for a fortress the Mole is influenced by the available supplies of food and water, but probably all other incidents of its surroundings are accidental. In the vast majority of cases the fortress is placed in an open field, but occasionally in a coppice, a hedgebank with an adjoining ditch, a hollow amongst old roots, or under a tree—in the latter case probably without definite choice or intention.

The "high-road," although a very important part of the domain of the male, does not differ essentially in its construction from the other routes and excavations, but only in being more frequently used, so that its walls are beaten until they become smooth and compact. It extends from the fortress to a distance in a nearly direct line, forming in fact the main route of communication between the fortress and the different parts of the encampment; and the alleys which lead to the hunting-grounds, or quarries, open into it on each side. All the runs, whether ordinary or high-roads, are large enough to allow two individuals to easily pass each other. It seems likely that they must sometimes do so, although the popular belief is that moles never intrude upon each other's company, and that, should two of them meet, one must retreat, or a battle to the death ensues. Probably, however, like another burrowing mammal, the Pocket Gopher[1] of North America, the Mole also has the power of running backwards tail foremost in its galleries, but only two writers—J. L. Knapp[2] and Captain Mayne Reid—have mentioned this possibility. It is also very supple, and can easily turn right round in any part of its tunnels. The high-road is probably formed at a greater or less depth from the surface, according to the nature of the soil, its humidity and hardness. Thus, where the soil is soft, it will be found at a depth of about four or five inches; but where the ground is hard, as under a road or beneath a stream, the earth is left not less than a foot or a foot and a half deep above it.

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[1] *Geomys lutescens*, C. Hart Merriam, *North American Fauna*, No. 8, 16, 31st Jan. 1895. In this animal the short, nearly naked tail has been developed as an organ of touch.

[2] *Journal of a Naturalist*, ed. 2, 150, 1829.

"It is truly marvellous," writes Mr Adams, "how runs are made at all in such difficult ground as Bunter sandstone, where the spade will hardly penetrate, yet the Mole will make his accustomed runs, and turn out among the heaps of sand stones weighing over 4 oz., which is the maximum weight of a mole. Worms in this ground must be comparatively scarce, and, one would think, mostly found at the roots of the grass at the surface, yet in this formation the runs are always very deep, often nearly a foot below the surface, and very wide."[1]

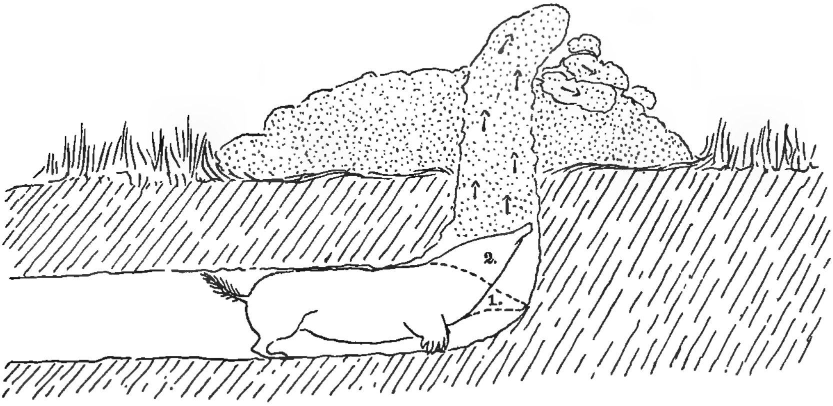

FIG. 21.—MOLE HEAVING UP LOOSE EARTH (diagrammatic; after Adams).

It is not quite clear how the soil is pushed out of the ground in making a heap. Mr F. R. Rodd[2] described the heap as rising very gradually with a motion from the centre exactly as flour does in a pan with yeast, a puzzling process which led him to suppose that the only way the work can be done is either by the animal standing almost on its head, or else throwing the earth up with its hands. So far, neither method has been confirmed by observation, and Mr Adams, following Capt. Mayne Reid, doubts the possibility of the earth being kicked out by the hind legs. After watching captive specimens, he believes that the earth is thrown out by the head, which a digging mole is constantly raising and lowering.[1]

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[1] R. Kearton's *Wild Life at Home*, 1899, 128, contains some remarkable statements as to the great strength of the animal.

[2] *Zoologist*, 1872, 3182.

The swiftness with which a mole will traverse its domain by means of the principal road is illustrated by most writers by reference to the famous, but doubtless exaggerated, story of the "trotting horse," a test instituted by le Court. Cold truth, however, reduces the rate of progress, often seen at best speed above ground by Mr Adams, to a pace never faster than a slow walk, or about two and a half miles an hour. Even if this, as is probable, can be exceeded in the tunnels, especially under the excitement of a stimulus like le Court's *cri effroyable*, there would still remain much scope for imagination before the animal could be affirmed to rival a horse at full trot.

The alleys or galleries are opened from the sides of the high-road in all directions and without definite plan. As already stated, they differ from it only in the fact that they are used less frequently. Mr Adams believes that in forming its runs, or excavating its quarries, the Mole at first simply digs its way through the ground, paying no attention to the loose soil. After a time it retraces its steps, and when returning pushes the loosened earth before it till the accumulation blocks. It then makes its way to the surface through the solid earth, opening a new shaft, over which a hillock is gradually formed by the successive portions of earth which are brought from the scene of its mining operations.

But the labours of the animal are not confined to the deep excavations already mentioned. In summer, when land newly sown is consequently light and yielding, and moderate rain

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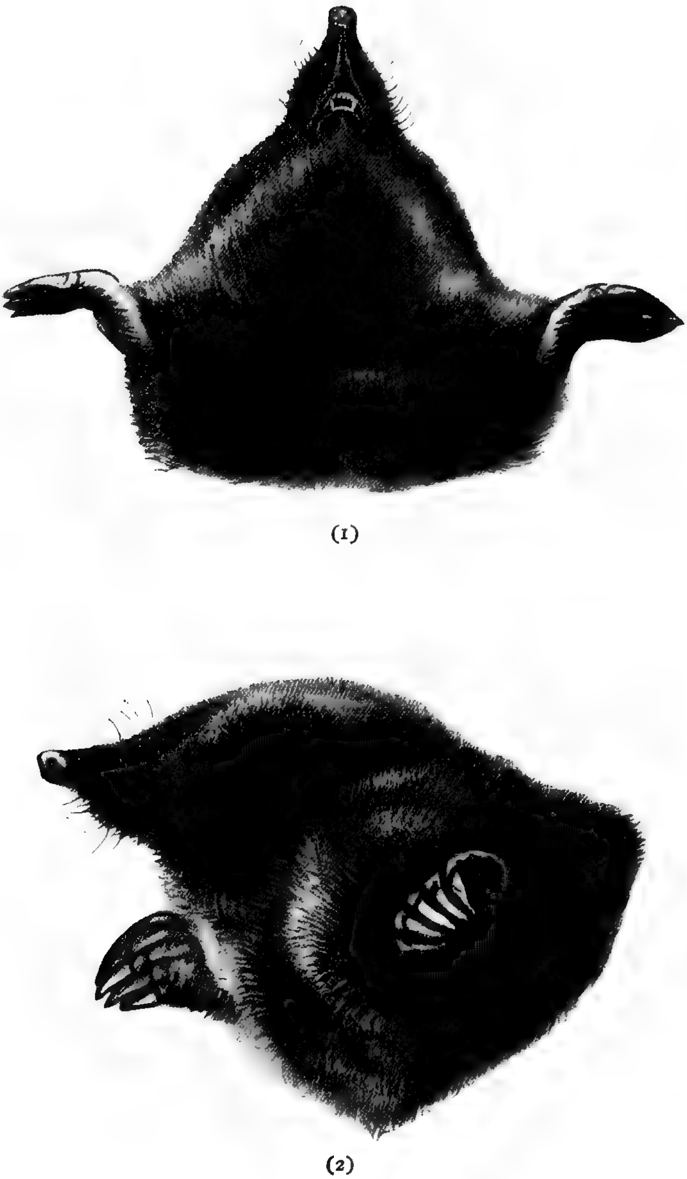
[1] The *modus operandi* of the Pocket Gopher, as observed by Merriam (*op. cit. supra*) from a captive specimen, is worth noting here. The animal differs, however, from the Mole in being a rodent with large incisors and fore feet of quite distinct type. When constructing a tunnel it uses its incisors as a pick, its fore feet both in digging and in pressing the earth back under the body, and its hind feet for moving the earth still farther backward. When a sufficient quantity of earth has accumulated behind it, it "turns in the burrow and by bringing the wrists together under the chin, with the palms of the hands held vertically, forces himself along by the hind feet, pushing the earth out in front." When an opening is reached the earth is discharged, but exactly how is not stated.

PLATE I.



THE MOLE.

HEAD AND FORE LIMBS—(1) Ventral and (2) Side View (magnified).

has brought the earthworms to the surface, it follows them, and pursues its chase along the superficial layer of the soil, digging a shallow continuous trench, in which work it advances with great rapidity. This is done by merely forcing its way through the light soil, and thus lifting it up; at such times the mole-catcher steals softly upon it and throws it out of the ground with his paddle. But great quickness is necessary in doing this, for a mole will bury itself again so rapidly as often to escape, even when fairly thrown on to the surface. In these shallow surface-runs the soil falls away on each side, leaving the creature's back exposed to view. There is no evidence to connect such runs with the gravid female or with the breeding of the animals; they owe their existence rather to the position of worms and grubs and the wetness of the soil. Mr Evans informs me that he has seen and captured a mole when burrowing amongst dead beech leaves, a favourite habitat for certain kinds of worms.

In summer the Mole works hard and continuously, and its tell-tale upheaving of soil may be seen at every hour of the day.[1] Yet its work is often less conspicuous than in winter, probably because worms are more easily caught and the need of new tunnels to secure them is, therefore, not pressing. In fact, the multitudes of worms on the surface in their pairing season are alone worth hunting, so that the runs are often deserted and the easier pursuit taken up above ground. The animal's thirst, too, must be satisfied when water is scarce. This is the time when its diet is most varied, slugs and snails being frequently captured, with an occasional vertebrate; but the tables are sometimes turned and the Mole itself killed and eaten, especially when it neglects to get below ground before daybreak.

Occasionally a mole's tracks are seen on snow. They resemble the impression that might be made by a rope two and a half inches in diameter dragged along the surface, with the marks made by the hind feet and the claws of the fore feet sometimes visible, to indicate the direction. Such wanderings may be due to movements of worms, in consequence of the hardness of the soil, but certainly not directly to the state of the ground, since Mr Evans has watched the heaps being thrown up during times of severe frost. Sometimes a mole passes along the surface of the ground beneath the snow, "making a sort of gutter of a run."[1]

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[1] E. D. Cuming, *Arcadian Calendar*, 17.

The Mole is a capable, if not a willing,[2] swimmer, and it has many times been observed in water, either escaping from a flood, changing its hunting-ground, or even occasionally enjoying the luxury of a bath.[3] Sometimes it ventures to face a river or lake,[4] even when of considerable extent; but examples which have been encountered swimming in the middle of a loch such as Morar[5] in Inverness-shire—traversing an expanse of water a mile and a half wide—must surely have been out of their depth both geographically and hydrographically, or they would never have attempted such a feat. Mr Adams describes a captive as swimming with the entire head and back to within half an inch from the tail high out of the water, and the end of the tail protruding above the surface. The movements of the limbs are very rapid, they work downwards and backwards after the manner of a dog, and the animal attains a fair pace in proportion to its size. Like other voracious feeders, it requires to drink frequently, but the belief that its runs are always connected with the nearest ditch or pond for that purpose, is only in part founded on fact, so that it must obtain sufficient water with its food, or, perhaps, by night from the dewy herbage.

There can be no doubt that the Mole feeds almost exclusively on invertebrates, and that the principal objects of its search are earthworms. It will consume, however, practically anything living that may come in its way, and mice, birds, lizards, frogs, or snails, if placed within its reach, become speedy victims to its voracity. But it is absurd to think that an animal of such structure could make an habitual practice of pursuing vertebrate animals.

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[1] Owen Jones, *The Scout*, 25th February 1911, 488.

[2] A. H. Cocks found one with which he experimented only a very poor performer.

[3] Bell, ed. 2, 130-131; Thomas Southwell, *Zoologist*, 1888, 22.

[4] E. Parfitt, *Zoologist*, 1860, 7169; S. D. Hine, *Field*, 24th June, 1876, 729; George Hales, *Journ. cit.*, 4th September 1880, 360; James Carter, *Journ. cit.*, 16th April 1892, 545; Riley Fortune, *Journ. cit.*, 23rd April 1892, 585; G. Hill and B. F. Edyvean, *Journ. cit.*, 30th April 1892, 625; W. Soundy, *Journ. cit.*, 14th May 1892, 704; Max Peacock, *Naturalist*, 1901, 44; W. A. Dutt, *The Norfolk Broads*, 127 (see *Zoologist*, 16th May 1904, 186-187); G. C. Williams, *Field*, 29th July 1905, 200, and many other references.

[5] A. P. Morres, *Zoologist*, 1877, 440-441; G. Hill, *Field*, 30th April 1892, 625.

Individuals must vary considerably in their habits and practices, since the Rev. A. Woodruffe-Peacock[1] informed Mr Adams that he had known moles to seize some young pheasants and a young blackbird by the feet in the shallow runs, and his brother found a hooded crow picked clean, the tracks on frozen snow clearly identifying the diner. Whether, as suggested by Mr C. Witchell,[2] it is an enemy to snakes or vipers in their winter sleep is, however, quite uncertain. Alston[3] offered a small toad to a captive mole, but it was rejected after examination; but, as a general rule, toads, as regards edibility, occupy a class entirely by themselves. To all other creatures, not excepting the weaker of its own species, the Mole exhibits a savage and unreasoning ferocity, and if two be placed together in a box without a plentiful supply of food, the weaker will soon fall a prey to the stronger. No bulldog keeps a firmer hold of the object of its attack than the Mole.

The Mole has been accused of feloniously burrowing under the nests of pheasants and partridges, "not by accidentally coming across them in its working, but working up to them to get at them."[4] It is probable, however, that the letting down of the eggs is in reality accidental, and that the sole attraction in such cases is the moist soil and plentiful supply of insects.

This is the view of Mr Owen Jones, who has had great experience as a gamekeeper, and who writes me that, although he has had any number of nests upset and the eggs let down into the tunnelling, he has never seen any evidence to show that moles directly meddle with them. He once took a clutch of uninjured pheasant's eggs[5] from a run underlying the nest;

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[1] A similar instance is narrated in the *Field* of 16th February 1901, 226, by C. A. Hamond.

[2] *Zoologist*, 1883, 293-4.

[3] *Journ. cit.*, 1865, 9707.

[4] C. E. Wright, in Adams; see also W. S. Medlicott, *Field*, 29th April 1905, 726; and for similar treatment of a partridge's nest, F. Dent, *Journ. cit.*, 17th August 1901, 312. Dogs are said not to be able to scent sitting birds, but the odour of the nest may be much more perceptible from beneath than from above, and eggs appear to suddenly acquire a strong odour just before the end of incubation (see below, under Hedgehog, pp. 63 and 67).

[5] *Ten Years of Gamekeeping.*

and the excavations of a mole beneath her caused a woodcock to forsake a clutch of eggs which came under Mr Evans's observation, although they were only moved slightly.

In spite of the obviously worm-eating character of the animal, many writers, amongst them le Court himself, have stated that vegetable substances may form no inconsiderable part of its diet. The roots of the artichoke, together with turnips, potatoes, carrots, and the young fibres of trees, have all been mentioned in this connection. Such statements, however, have always been received guardedly, if not incredulously, by naturalists, who have pointed to the extreme gluttony and raging frenzy of a hungry mole as exhibiting none of the characters of a vegetarian or even of a mixed feeder, and have concluded that the vegetable matter discovered in its stomach must have found its way there accidentally during its digging operations. However that may be, the suggestion that it may be partly herbivorous, although improbable, is not absolutely untenable, since we know that other insectivores, are certainly in part vegetable feeders.[1]

Like shrews, adult moles are very impatient of starvation, and die very soon if left without food. Mr Adams states that on one occasion he caught one, vigorous and quite unhurt, and fed him at intervals during the day with about a third of a pint of worms. Having placed a similar quantity in his den (a packing-case with earth at the bottom), he left him for the night. "In the morning I found him very feeble, thin and cold. I took him up in my hand and put his nose to some water, which he seemed to enjoy, but he was too feeble to tackle a worm, and presently, after a gentle convulsion, he died in my hand. I found on dissecting him that the stomach was absolutely empty, in spite of the fact that he had eaten every worm left for him. Baby moles, on the contrary, live a surprisingly long time without food;[1] in fact, their capabilities of resisting starvation vary inversely as their size, the irregularity being perhaps accounted for by some having fasted longer than others before being taken from the nest."

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[1] This is stated to be true of the Japanese Mole-Shrew (*Urotrichus talpoides* of Temminck; see Oldfield Thomas, *Proc. Zool. Soc.* (London), 28th November 1905, 341-342), and of the American short-tailed shrews of the genus *Blarina* (see C. Hart Merriam, *Vertebrates of the Adirondack Region*, ii., 71, 1884; also E. Thompson Seton, ii., 1126, etc.); the latter will eat beech-mast, oats, and corn meal. North American agriculturists have recently become alive to the fact that the animal which does duty with them for the European Mole (*Scalops aquaticus*) may sometimes consume such quantities of corn as to cause considerable damage to farmers. (See R. L., *Field*, 11th February 1911, 281, where references to some American publications are given, but I have been unable to find the originals.)

Although it has been stated above that the Mole makes no provision for the winter, it must not be forgotten that many writers allude to stores of injured or paralysed worms which are supposed to have been collected for future use. The belief is said to be widespread amongst mole-catchers, but, so far as I can gather, appears to have been first printed by Edward Jesse.[2] An anonymous writer[3] on the same subject has been often quoted. This writer declared that when in company with a man employed to poison moles, which he did through the medium of earthworms, he observed him obtaining his bait from cavities in the largest molehills of a marsh in Norfolk. The cavities were round and "beaten hard by the mole so as to prevent the escape of the worms." This story was received with incredulity by Edward Newman,[4] and doubted by the late Thomas Southwell.[5] Like many other statements advanced by untrained writers, it would appear to be the result of imagination rather than an invention. Although no trained zoologist has had the good fortune to examine such an undoubted store of worms,[6] many have found smaller "knots" or accumulations of them. Southwell believed that such worms are merely individuals which, from one cause or another, have found their way into disused runs from which they have been too feeble to escape. What has been pointed out to him as an injury inflicted in order to disable the worms, has invariably proved to be the series of thickened segments known as the clitellum. The flaccid, unhealthy appearance of such worms, as noticed by Southwell, is independently corroborated by Mr Adams, who sees nothing unusual in the matter, since he has frequently, in digging his garden, come across similar knots or bunches of pallid, sickly looking, semi-torpid worms. In early spring he has often found a similar knot of worms, three or four in number, embedded in a semi-torpid state in the solid earth of fortresses, where he believes they had congregated of their own free will. He has never met with knots of worms in the tunnels, and concludes that their presence in a fortress is explained by their having fallen in and been unable to get out again.[1] But, although there is thus no trustworthy evidence supporting the theory that moles store up worms, it is interesting to find that they possess the instinct to do so. Alston's captive often buried its food, and Mr Adams relates that on one occasion when he had fed one until it could eat no more, it took a worm, bit it with quick bites along its whole length, crammed it into the earth, left it, and turned about to find another.[2] On receiving one, a large lobworm, it treated it in precisely the same manner, thrusting it into the same hole and straightway covering it up with earth scraped over it with its fore paws. On two other occasions this mole was observed to bury worms, and once a dead mouse, in the same way. On the whole, it seems unlikely, although the Mole may sometimes disable and bury surplus worms, that its victims should when thus treated remain alive for a sufficient length of time to be of use as a reserve of food.

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[1] See also H. Laver.

[2] *Gleanings in Natural History*, 6th ed., 136, 1845.

[3] *Field*, 13th March 1875, 267.

[4] *Zoologist*, 1875, 4493.

[5] *Journ. cit.*, 1888, 21.

[6] The nearest approach is the statement of a farmer to Adams, that he found "three spadefuls" of dead worms heaped up in the nest-cavity of a fortress.

There are many errors in the ordinary accounts of the breeding habits of the Mole, the most serious being the belief that males are much more numerous than females. The mistake arose from the fact that, as pointed out by Geoffroy, it requires expert knowledge to distinguish the sexes externally. Mr Adams finds that males and females are about equal in numbers, which fact obviates the necessity for the supposed bloody battles between the superfluous suitors as described in text-books.[3] There is only one short rutting season. This is, in Staffordshire, practically confined to the latter part of March, April, and perhaps occasionally the beginning of May. Mr Adams's earliest personal record for a fœtal litter is 13th April, and he has notes of young found in the nest from 24th April (on the authority of a mole-catcher), 4th May (about seven days old, his earliest personal record) to 25th June (his latest record). The latter were almost ready to leave the nest, and were, therefore, at least three weeks old.

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[1] This is also the explanation given in an interesting paragraph on this subject in W. A. Dutt's *Wild Life in East Anglia*, 183, 1906.

[2] Captive shrews act in a similar manner (Cocks, *in lit.*).

[3] A fight between two males took place, according to Mayne Reid (*op. cit. supra*, p. 19), above ground on a 21st December.

Practically all the young, therefore, are born within the period commencing about 24th April and ending about 4th June.

The fact that the runs made by the two sexes are distinguishable, shows that they usually live apart; but during the breeding season the males leave their own long straight runs, and are found in the winding tunnels which are the work of the female. Here, no doubt, pairing takes place; as it may, possibly, also above ground, as once observed by a keeper who informed Mr Adams.

Very similar results have been independently obtained by Mr Evans, working in the Edinburgh district, and by Mr Cocks in South Buckinghamshire. Mr Evans found embryos from the 7th April onwards, and, on the 24th May, young which he judged to be about a week old. Mr Cocks reports embryos from 14th April to 20th May. On the 21st May two young ones were captured, of approximately three-quarters full size, so that they were probably born about the 1st of May; and in 1877 two litters (of four and three) were found on the Berkshire side of the Thames at Bisham on 28th April. Mr Cocks remarks that, whereas the embryos examined in April showed only a very little variation in size, some found on 14th May were younger than those of a month earlier, and others found on 20th May only equalled the size of a fœtal litter found on 18th April, or over a month previously.

Calculating that the period of gestation is four weeks, or rather more, Mr Adams thinks that "the female would not have time to breed twice within the period mentioned during which young are found, even if she were in condition to do so, which she is not. Moreover, these limits are not those of the same year or locality, so they may be fairly curtailed, and a month of courtship may be presumed to be the limit of the Mole's capacity." On the other hand, there may be a few exceptional cases, probably of young animals, breeding later, which might account for Mr F. G. Aflalo's "young in August."

The female constructs a quite separate[1] fortress and nest in which to bring forth her young. This is usually, but not always, of simpler construction than the fortress of the male, and seldom possesses a bolt-run. Mr Adams, however, has sent me a description of one—so far unique in his experience—in which there were two bolt-runs. He has also figured a breeding-fortress in which there were two inhabited nests, each with a bolt-run. Although de Vaux says without hesitation that moles live in pairs in the habitation of the male until the female leaves her spouse to prepare her nursery, Mr Adams is by no means convinced that this is the case. He has "never been able to trap a female in or close to a male's fortress, and if we are to judge from the analogy of the rabbit (which makes a separate nursery, presumably to protect her young from the voracious father or fathers), we may suppose the Mole to be polyandrous."

"As far as my information goes," writes Mr Adams, "no mammal prepares a nursery till well advanced in pregnancy; if this holds good with regard to the Mole, six weeks is nearer the actual period of gestation than one month, as some fortresses from which I have taken the young have been made about one month previously."[2]

The average number of young in a litter, according to Mr Adams's experience, works out at rather more than $3\frac{1}{2}$.[3] To find two is very rare, and he has only in a single instance met with a solitary young one. The greatest number is six, which is also very occasional. He has heard of seven. The following table gives his personal records:—

Number of litters containing one .	1	Number of litters containing four .	31
" " " two .	4	" " " five .	4
" " " three	20	" " " six .	1

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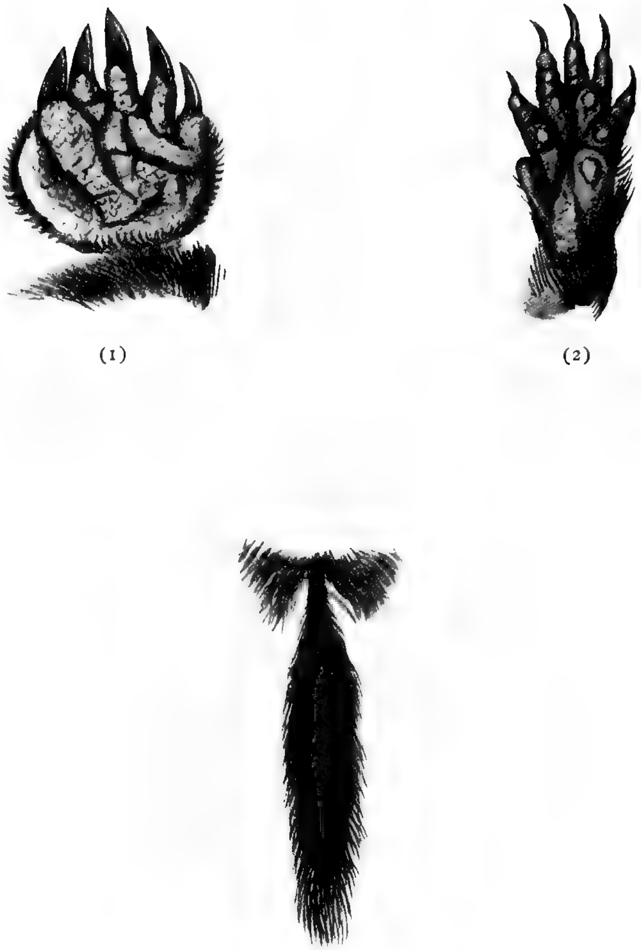
[1] See Mrs Rose Haig Thomas, *Field*, 3rd October 1903, 600.

[2] Adams has since sent me a note of a nursery made only four days before it was occupied by young.

[3] Twenty-one pregnant Scottish females gave Evans an average of 3·86 embryos, and Cocks found an average of (exactly) 4 embryos in nine females, or, including the seven young in two litters mentioned on the previous page, an average of 3·9.

PLATE II.



(1) (2)

(3)

THE MOLE.

(1) LEFT HAND AND (2) FOOT, AND (3) DORSAL VIEW OF TAIL
(magnified 1½ times).

The young, which are hairless at birth, grow so rapidly as to double their length within the first ten days of their life. At about the ninth day the advent of the fur is heralded by a change of hue on the back from pink to dull lead colour. On about the fourteenth day the fur begins to make its appearance, and by the twenty-second it is of normal length and colour. The ears open on about the seventeenth day and the eyes on about the twenty-second day, soon after which the young are nearly as big as their parents. They probably leave the nest in or after the fourth week. Mr Adams's interesting observations on this point, which are printed above in tabular form on p. 12, were interrupted by the fact that the nests in which he measured young moles were all eventually found empty at various dates before the conclusion of his investigations. The circumstances suggested removal of the young by their mothers.

The ancients in general appear to have had but vague notions respecting the habits and structure of animals; from this charge Aristotle is in an astonishing degree exempt. It has, however, been adduced as an instance of erroneous and superficial observation, that he held the Mole to be absolutely blind. In this, however, as has appeared above, he certainly wrote quite correctly of the species found in southern Europe; but Shakespeare[1] was on more treacherous ground when he laid such stress on this aspect of the animal in describing "The blind Mole" which "casts copp'd hills towards heaven." Numberless minor superstitions are current concerning the animal: it cannot live where Irish earth has been spread; in Staffordshire it possesses only one drop of blood;[2] in Surrey it has but one ear; in Lincolnshire it leaves the ground only once a year to take a little fresh air by daylight;[3] in Scotland its burrowing near a house betokens the speedy departure, or even death, of the inhabitants.[4] In many places people believe that moles wandering above the earth are "moonstruck";[5] while it is on record that a mole's heart swallowed warm and palpitating confers skill in divination, and that a sprinkling of the blood makes a crazy person sane.[6] It will be appropriate to mention here the picturesque prophecy of the Scottish soothsayers,[1] that when the moudiewarp has overrun Argyllshire to the Mull of Kintyre, it will drive all the Campbells, the great landowners of the district, from their estates.

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[1] *Pericles*, i., 1.

[2] Adams.

[3] *Fide* C. B. Moffat (*in lit.*).

[4] A. R. Forbes, *Gaelic Names of Beasts, etc.*, 1905, 188.

[5] J. G. Millais.

[6] Cuming, *Arcadian Calendar*, 182.

The Mole has always been the object of the most determined persecution on the part of farmers and gardeners, who accuse it of causing injuries, more or less serious, to the various products of the soil. The truth of each accusation must, as Mr Adams observes, vary with the circumstances, but it cannot be denied that a heavy list of indictments can be registered against it. Even after excluding the assertion that it causes inundations, which can be but seldom; and the somewhat far-fetched suggestion that it encourages mice by leaving them its deserted fortresses; there remains the destruction of the crops by disturbance, exposure, and severance of their roots, or by their being dug up or scattered and carried off bodily to the fortress to form part of the nest. No part of field, garden, or plantation is exempt from these ravages, and de Vaux estimated the loss to the spring corn in France at not less than one-eighth of the whole crop. Sometimes a field is so extensively mined that the area covered by molehills appears to exceed that of the vegetation, and their presence, even in small quantities, is a great obstruction to mowing. Against accusations such as these the mere condoning of the damage, the suggestion that the contents of molehills spread on the fields afford excellent topdressing, or the assertion that the injuries are counterbalanced by the benefits rendered through aeration of the soil and the destruction of noxious insects, are of little avail. The fact of the devastations cannot be denied, even if the degree and extent of them be incorrectly reported, and few farmers would like to see moles on their land for the sake of any problematical advantages accruing from their presence.

The history of the efforts made by farmers to cope with the damage done is probably as old as that of tillage or haymaking. Fanciful hints as to the destruction of the animals were compiled in Latin by Palladius,[2] probably about the fourth century, and

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[1] Alston, *Zoologist*, 1867, 882; according to Boyd Watt (1905), the Mole is said to have spread to Campbeltown only recently, and not yet to be known in Southend.

[2] *Op. cit. supra*, p. 6.

Mr J. E. Harting has seen an entry of the wages paid to men who spread molehills in England in 1480.[1] On the other hand, the late Robert Service stated[2] that mole-catching as a regular trade did not begin in South Scotland until 1797. A minute investigation of the history of mole-catching is here impossible, but reference may be made to Macpherson's work for an account of it in Lakeland, where the practice was certainly in vogue in 1612. The animal was hunted down either privately, or in some cases by the residents of a locality clubbing together. The mole-catcher was often employed by the parish, so that the amounts which he received appear in the churchwardens' accounts of most parishes for the seventeenth century. Generally a penny a head was paid, but at Harrold (Bedfordshire) the mole-catcher's remuneration was £2 a year.[3] It appears that a mole-catcher was still paid by the Cambridgeshire parish of Dry Drayton in 1880,[4] but Mr Adams remarks, not without reason, that the whole race would have long since vanished, with the objects of their pursuit, had they directed their attention to the destruction of the young in their nests instead of confining themselves to trapping the adults.

So strong is opinion against the Mole, that the humble profession of mole-catcher has become celebrated; and the followers of this calling are said to earn a considerable income in a season at a trifling sum for each animal captured. One trapper named Jackson, with whom Bell was in communication, declared that he had destroyed from 40,000 to 50,000 moles in thirty-five years. Jonathan Couch informed Bell of another who in Cornwall took no less than 1200 of these animals in six winter months; while, according to Dr Laver, the two brothers Watchem (or Watsham) have secured no less than 1500 fresh skins in a single season at Colchester. But all others must yield to le Court, who in the short space of five months accounted for no less than 6000 moles within a comparatively small district; and two of his pupils, during the month that they were under his instructions, killed 971.

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[1] *Zoologist*, 1887, 445.

[2] *Ann. Scott. Nat. Hist.*, 1896, 202.

[3] J. Steele Elliott, *Zoologist*, 1906, 254.

[4] Rev. F. A. Walker, D.D., *Journ. cit.*, 1891, 392.

It really seemed as if it were impossible that a mole could escape this extraordinary person; wherever he struck his paddle, he found the mole's run; wherever he placed his trap, the mole was surely taken. His trap was of simple construction. It consisted of a steel instrument bent on itself like a pair of sugar-tongs, excepting that the branches crossed each other about their mid-length, so that the elasticity of the bend brought the extremities forcibly outwards and towards each other. The branches were held asunder by a square piece of iron with a hole through it, which the slightest touch would displace; and the animal, running along its passage, threw the trigger, as it may be called, and was caught by the branches springing sharply together. This appears to have been a very simple, certain, and effectual instrument; but it has been considerably improved upon in a trap now much employed in this country, in which the hinge, connecting the two branches, is placed in the middle, the spring behind, and the trigger before the hinge. A sort of box-trap has been recommended in some places, but it has the defect of being less certain; and at the same time it is not free from the objection of cruelty, as the animals are taken alive, and when several are confined in the trap together, they fight in the most desperate manner, wounding and even destroying each other. In the centre of England a very effective and simple trap is made by sticking into the ground a hard-wood stick, three or four feet long, to the free end of which a loop of fine brass wire is attached; the stick being bent down, the wire is made to pass through a hole in a small piece of board, into which a peg is introduced from below, to prevent the wire from being withdrawn by the elasticity of the stick. The board is so placed as to form a small portion of the roof of the run, and is firmly kept in position by sticks laid horizontally across it, which are held down at their ends by hooked pegs. The loop of wire passing through the board is opened below, so as to fit the inside of the run; and the peg, which keeps it from being drawn up by the spring-stick, projects downwards into the middle of the run. The mole, passing along, pushes out the peg, whilst its own body is within the wire loop, which is instantly drawn up, and the creature is speedily killed. The Scottish mole-catchers, as Mr Evans informs me, use, instead of the board, a tubular piece of wood representing a short section of the run.

The Mole, owing to its underground abodes and the greater facility with which other animals which lie above ground can be procured, has, at least in Britain, few enemies. Dogs and foxes occasionally dig it out. Most of the short-winged hawks and owls—as shown by the bones occurring in their pellets—snap one up now and then when venturing above ground. Weasels,[1] and more rarely stoats, have been found or caught in the runs and have been seen carrying dead moles,[2] and sometimes they take possession of a fortress. But it does not appear to be proved that any of these animals make a systematic practice of mole-catching,[3] and in captivity, as Mr Cocks informs me, they will only eat mole-meat when exceptionally hungry.

Moles have been occasionally kept for a few days in captivity, and they thrive well enough if they are supplied with a warm, dry bed, and if their inordinate hunger and thirst receive the constant attention which is essential. Young ones may be taken from the nest at any age and reared on cow's milk, which they drink readily. Their treatment presents no difficulties to people who are accustomed to look after young animals, so that it need not be described in detail.

Alston[4] wrote a graphic account of one which he kept for nine days. It was the fiercest, boldest, and most voracious of animals. When regaled with the body of a frog it appeared to be possessed of a devil. It literally danced round its victim, worrying and biting at the skin of the belly until it tore it open, after which it feasted sumptuously on the entrails. This mole often carried its food underground; dragging the piece of meat to its heap of soil, it dived beneath it at one side, then turning itself, thrust out its head and pulled down the food after it. When it fed above ground its head was drawn back, its back arched, and its hands or fore paws turned so as to hold down the fragment, at which it tore with its little sharp teeth. Sometimes it fell asleep over its food, and awoke with renewed appetite; generally, however, it retired underground to sleep, coming out to feed every few hours. "The most amusing thing was to see him dive into the earth; first he grubbed a hole with his snout, then a few powerful strokes of his digging paws concealed the fore part of his body, and then his hind feet gave a kick in the air and disappeared."

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[1] As known to Gilbert White (Letter xl. to Thomas Pennant, 2nd September 1774)—"Weasels prey on moles, as appears by their being sometimes caught in mole-traps."

[2] H. Harden-Simpson, *Field*, 1st May 1886, 570.

[3] A. H. Patterson, *Nature in Eastern Norfolk*, 311, 1905; also Knapp and Dutt, *op. cit. supra*, suggest that they do.

[4] *Zoologist*, 1865, 9706-9708.

One which Mr Adams kept alive in good health and vigour until, after eight days, he released it, was an enormous eater. When its food was a worm it would first seize it with its mouth and, holding it down with its paws, would feel the way with its snout to an end, as often one as the other, after which it would consume it from end to end by a series of short, quick jerks, now and then giving it a preliminary brushing with snout and paws to remove the dirt.

"On one occasion a large lobworm had burrowed nearly out of sight, when the mole came upon it, seized it, but instead of tugging at it furiously, as I had expected, and thereby breaking it, he held it taut, and presently yielding to the gentle tension, it was secured whole. This knowledge of the fragile nature of a worm, to say nothing of the ultimate consequences of haste and fracture, is remarkable, and the self-restraint on the part of so impetuous a creature is still more so."

Worms were undoubtedly the favourite food of this individual, but it also ate slugs without hesitation. It was offered freshly killed mice, but would only tackle them when there were no worms available, and then only when slit open. The heart, lungs, and intestines were the only parts touched.

Another account of a captive mole by the late Mrs Eliza Brightwen[1] differs from that of Mr Adams as regards the animal's method of eating worms. He pounced upon one "with the fury of a tiger, and holding it in his mouth, tore it to pieces with his sharp claws and rapidly devoured all the pieces, and snuffing about to make sure he had quite finished it, he then darted off to seek another." This mole kept his velvet coat carefully brushed and licked by a tiny red tongue.

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[1] *Wild Nature won by Kindness*, 133, 1896.

It is doubtful if such intelligence as the Mole possesses is, apart from its ordinary routine, of a high character. It seems to know how to avoid anything tainted by the touch of human hands, so that mole-catchers rub the inside of a trap with a dead mole before setting it, but the rapidity with which it becomes indifferent to being handled is suggestive of a dull brain. "When first caught," writes Mr Adams, "they squeak and bite viciously, but within an hour I have taken them up by the skin of the back without their protesting. I have frequently stroked and tickled my captives while they were engaged in eating, and I have held them up by the tail while they lapped water. I taught my last captive to come blundering along for food when I scratched upon the earth or the side of his box."

When angry or alarmed, moles can squeak[1] in a loud, shrill fashion, recalling the voice of a bat or shrew. But they have also other notes, one of which Mr Evans describes as somewhat like the purring of a cat or the distant jarring of a nightjar.

Mr Adams is nothing if not thorough in his studies of his favourite animal, so that it is not surprising to find him testing the gastronomic qualities of mole-flesh, with the result that he found baby moles excellent eating, "much like rabbit, the flesh being white and very tender."

Mole-skins were formerly accounted of some value, and even in times of depreciation, according to Mr Henry Poland, several thousands changed hands annually, at a price of about one penny to a penny farthing each, to be made up into waistcoats. One so made was composed of no less than fifty skins, and was highly commended by the editor of the *Field* for its lightness and warmth. Of late years, as I am informed on excellent authority, a fluctuating demand has arisen for the skins in the manufacture of ladies' coats.

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[1] Alston, *Zoologist*, 1865, 9708; also, R. F. C., *Field*, 6th May 1876, 501.

Note.—Owen Jones has printed (*Ten Years of Gamekeeping*, 298) the description by an eye-witness of a mole gathering material for its nest:—"I heard a rustling quite near me. I thought it must be a mouse. . . . Another rustle, and I saw a dead oak-leaf move. I sank on my knees, and crawled to the spot. Within a yard of my face I saw the pinky snout of a mole : never was more than the snout and head . . . to be seen : its body remained in one of those shallow surface-runs. With amazing swiftness the snout felt all round, and each dry leaf within reach would be grabbed and drawn under : in about ten seconds the mole would return. When there were no more leaves within reach of one opening, the mole would thrust through the surface in a fresh place, and continue its leaf-gathering with incredible energy." R. Kearton (*Wild Life at Home*, 129, 1899) states that he has once or twice seen moles come out for leaves, but he gives no description of their movements.

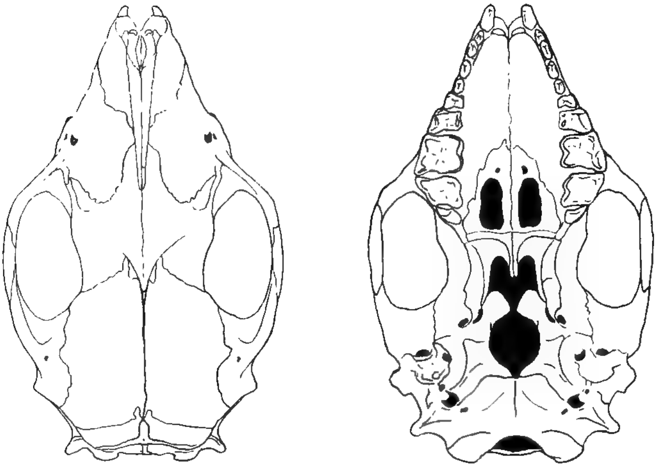
(*a*) (*b*)

FIG. 21 A.—SKULL OF HEDGEHOG, *Erinaceus europæus.* (*a*) from above ; (*b*) from below. Drawn by G. Dollman.

ERINACEIDÆ.

TRUE HEDGEHOGS.

GENUS ERINACEUS.

1758. **ERINACEUS**, Carolus Linnæus, *Systema Naturæ*, x., 52; xii., 75, 1766; based on *Erinaceus europæus* of Linnæus.

1868. **HERINACEUS**, Minà Palumbo, "Cat. Mamm. Sicilia, in Ann. Agr. Sic., 2nd ser., xii., 37." (Not seen; thus quoted by Palmer.)

THIS genus, which includes one British species, is of wide distribution, and its many representatives are found numerously throughout Europe, Africa, and the greater part of Asia, but not in America, Madagascar, Ceylon, Burma, Siam, the Malay Peninsula, or Australia. Many of the species are very little known, but there may be mentioned my *E. roumanicus* (Matschie's *E. danubicus*), a dusky hedgehog with white breast-spot and peculiar skull characters, ranging from Bohemia and Roumania to Greece; Satunin's *E. ponticus*, with a subspecies *abasgicus*, which I have not been able to examine, described from western Transcaucasia; Schrenck's *amurensis* from Amurland; Erxleben's *sibiricus* from Siberia; Satunin's *ussuriensis* from the Ussuri country, Eastern Siberia, and *chinensis* from Chingan, Tyntza-intza, China; Swinhoe's *dealbatus*, a pale form from China (Peking, Chefoo); Matschie's *kreyenbergi*, *tschifuensis*, and *hunensis*, all from China, and Thomas's *miodon* and *hughi* from Shen-shi, China. Allen's *orientalis* from Vladivostok is said to be externally of *europæus*-like type, but with quite distinct cranial characters (see my paper in *Ann. and Mag. Nat. Hist.*, April 1900, 360-368). Bate's *E. nesiotes* of Crete is a somewhat small insular form.

The genus is not represented in America, but Matthew's *Proterix* (*Bull. American Mus. Nat. Hist.*, xix., 227, fig. 1, 9th May 1903), from the Oligocene beds of South Dakota, was described as indicating a "True Hedgehog" of ancestral type, apparently intermediate in form between *Erinaceus* and *Gymnura* of the old world. These were also thought by Trouessart to be connected by his *Neotetragus sinensis* from western China (*Ann. and Mag. Nat. Hist.*, October 1909, 389-391), but Thomas has since shown (*Proc. Zool. Soc.*, London, 1911, 162, published March 1911) that the true affinities of this form are with the gymnurine *Hylomys*, without any special leaning towards the Erinaceinæ.

Hedgehogs are of considerable antiquity, and date at least from the upper and middle Miocene of European strata. The ancient Egyptians have left drawings of a member of the closely allied *Hemiechinus auritus* (*Nature*, 30th June 1904, 208; see also Keller, p. 20, fig. 7).

Generic characters:—The true hedgehogs are short-tailed insectivora with rudimentary caudal vertebræ, imperfectly ossified palate, and wide pelvis.

The upper surface and sides of the **body**, but not of the tail and head, are covered with spines, and, by the help of a special development of muscles, the skin of the back can be drawn downwards and forwards over the head and limbs. The animal tucks in its head into the interior of the "ball" thus formed, and is protected on all sides from ordinary attacks.

The **spines** are longitudinally grooved, the intervening ridges being smooth.

The **hair** is harsh.

The **ears** are very short, always less than half the length of the head (Plate V., Fig. 3).

There are six to ten paired **mammæ**.

In the **skull** the pterygoid fossæ are well developed, with the processes not hollow and taking no part in the osseous bullæ; the postglenoid process is much smaller than the postmastoid, and its interior is solid, not hollow.

There are thirty-six **teeth** (Fig. 22, p. 54) arranged as—

$$i\,\frac{3-3}{2-2},\quad c\,\frac{1-1}{1-1},\quad pm\,\frac{3-3}{2-2},\quad m\,\frac{3-3}{3-3} = 36.$$

The canines and anterior premolars are usually described as single-rooted, but vary very much in this respect.

Northern forms hibernate, but not those inhabiting southern regions, such as India.

The most nearly allied genus is *Hemiechinus*, instituted by Fitzinger for hedgehogs having the ridges of the spines tubercled, and recently revived by Satunin (*Ann. du Mus. Zool. de l'Acad. Imper. Sci.*, St Petersburg, xi., 1906, published 1907), to include *auritus*, *albulus*, and other long-eared forms.

THE HEDGEHOG OR URCHIN.

ERINACEUS EUROPÆUS, Linnæus.

1666. *Herinaceus & Erinaceus*, an Urchin or Hedgehog, Christopher Merrett, *Pinax*, 167.

1758. *Erinaceus europæus*, Carolus Linnæus, *Systema Naturæ*, x., 52; xii., 75, 1766; and all British authors, except as below; described from Wamlingbö, South Gottland Island, Sweden; see Thomas, *Proc. Zool. Soc.* (London), 1911, 142, published March 1911.

1803. *Erinaceus suillus*, Étienne Geoffroy, *Catal. Mamm. du Mus. d'Hist. Nat.*, 67; described from France.

1803. *Erinaceus caninus*, *Auct. et op. cit.*, 68; described from France.

1900. *Erinaceus europæus occidentalis*, G. E. H. Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, April 1900, 362-363, and *Ann. Scott. Nat. Hist.*, January 1901, 3; described from Innerwick, Haddingtonshire, Scotland (type specimen in British Museum of Natural History).

Le Hérisson of the French; *der Igel* of the Germans.

Terminology:—The ordinary name of this animal, of which there are innumerable corruptions, is of a quite obviously English origin, though it does not appear before 1450. It occurs in a famous passage of Shakespeare:—"Thorny hedgehogs, be not seen" (*Midsummer Night's Dream*, II. iii. 10; see also *Tempest*, II. ii. 10, quoted below on p. 58, and (metaphorically) in *Richard III.*, I. ii. 104). On the other hand, it appears in the form *hedgepig* in *Macbeth*, IV. i. 2, in a passage quoted below on p. 74; and as *urchin* in *Titus Andronicus*, II. iii. 101:—"Ten thousand swelling toads, as many urchins."

But the old English name was none of these, the Anglo-Saxon form being *īl*, a contraction of *igel* (compare the modern German *igel*, a hedgehog).

Urchin is derived from Old North French (*i.e.*, Norman or non-Parisian French) *herichun*, a form which appears as *hurchin* or *hyrchoune* in Scotland, as in Barbour (Early English Text Society, edited by Skeat, xii., line 353), and has many variants in different counties. The Latin type from which this word is derived was *ericionem*, a theoretical extended accusative form from Latin *ericius*=a hedgehog; itself an extended form of Old Latin *ēr*=a hedgehog, cognate with Greek χήρ. *Ericius* occurs in the Vulgate.

Sex names:—Boar and sow.

Local names (non-Celtic):—*Furze-a-boar*, as in South Devon and Cornwall; *furze-man-pig* of Gloucester; *hedge-boar* or *hedge-pig* of Buckinghamshire, Somerset, Devon, Cornwall, South Worcester, and Wiltshire; *niceple*, *nisbil*, and *nyse-bill*, no doubt from the Anglo-Saxon *an ilespil*=a hedgehog's quill (*pil*=a dart), are, through popular confusion, employed as variants, as in Pembroke, and are all that now remains to represent the Anglo-Saxon *il; porpentine*, *perpynt* (?), *porcupig*, *pork-point*, and *porpin*, as in Pembroke and Somerset, being all derivatives of *porcupine* (itself from *porc-espin*); *prickle-back urchin* and *peggy-urchin* are longer forms of *urchin*, and have similar variants; *rock* (young) of Somerset; *sharpnails*.

(Celtic):—Irish—*gráineóg*="the horrent one," from *gráin*="loathing" or "aversion." Scottish Gaelic—*gràineag*. Manx—*graynag; arkan-soney* (Cregeen), both only found in dictionaries (Kermode). Welsh—*draenog*, *draened*="spiny one"; *draen y coed*="spiny of the wood"; *sarth* (?) *armell* (Pugh). Cornish—*sart*, *zart;* Mid-Cornish—*sort*=Welsh *sarth*.

Distribution:—Hedgehogs of this type range from sea-level to at least 8000 feet in the Caucasus (Blasius); and from about 63°, 61°, and 59° N. lat. in Skandinavia, Russia, and the Urals respectively, to the Mediterranean, including Sicily, Sardinia (Woltterstorff), Crete (Bate), and Asia Minor to Mount Lebanon; thence to Erzerum (Thomas), Trebizond, and probably right through to the Caucasus. West and east they are found from Ireland to Peking (Swinhoe), Aigun on the Amoor (Schrenck), the Ussuri country, and Vladivostok. A number of forms inhabit India, Afghanistan, Transcaspia, and Mesopotamia, in the two last of which, together with Cyprus (Bate), is found *Hemiechinus auritus* (Gmelin). *E. europæus* is not known from Arabia, Egypt, or Tunis, and in Morocco it is replaced by *E. algirus* of Duvernoy, which is also the hedgehog of the Balearics (Thomas and Pocock). An Andalusian specimen of *E. algirus* in the British Museum needs confirmation; perhaps, like a French record, it may have been due to introduction from the Balearics (see Siépi, *Feuille jeunes nat.*, Paris, 1909, 24-26).

In the **British Islands** *E. europæus* is probably common in every part of **England and Wales** (including Wight and Anglesey), the Lowlands of Scotland, and **Ireland**, where it has not been specially persecuted by man. In his first season as keeper in Hampshire, Owen Jones killed about one hundred and forty (*Ten Years of Gamekeeping*, 1909, 100). It is not particular about its surroundings, and frequents with impartiality the Yorkshire hills to at least 1300 feet (Clarke and

Roebuck), and the suburban gardens of big towns and cities. In Wales it has been found living at 1684 feet, and its dead carcase at 2500 feet (Forrest); but one said to have been found recently in Kensington Gardens, London (Harding, *Field*, 8th April 1911, 703), had most probably escaped from captivity. In **Man** it is now common everywhere, but, having no local names outside of dictionaries, is thought by Kermode to have been introduced early in the nineteenth century.

In the Lowlands of **Scotland** its numbers are certainly not less than in England. Alston, for instance, described it as "very common"; in Dumfries, Service has had no less than eight in full view within twenty yards (*Ann. Scott. Nat. Hist.*, 1901, 233); and close on a hundred were killed in 1903 on one estate near Edinburgh (W. Evans).

Its status in the mountainous parts of Scotland, although it ranges to the extreme north, is still somewhat obscure, and, now that it has been artificially introduced in many localities, is not likely to be satisfactorily explained. W. Evans collected a number of old records relative to the northern limits of its range at the close of the eighteenth and beginning of the nineteenth century. These are somewhat conflicting, but this much seems clear, namely, that the animal was at that time found well to the north both of the Forth and of the Tay. As pointed out by Evans, it was recorded for Tillicoultry, Clackmannan, in 1795; Dowally, near Dunkeld, in 1798; Forfarshire in "tolerable plenty" before 1813; and as far as the Moray Firth by 1828. Harvie-Brown and Buckley's "Moray" records of 1829, 1844, 1855, and 1862 show clearly that it was locally common in that area in the second quarter of last century. Its general reputation of late years is that of a species with an extending range, a point in regard to which many writers have been, perhaps, too prone to follow the lead of predecessors. In 1880 Alston recorded it as rapidly spreading to the northwards, but as yet unknown in Sutherland. Its status in that county, as well as in Caithness, is complicated by introductions, but there are records of its occurrence in the former by William MacKenzie (*Ann. Scott. Nat. Hist.*, 1897, 191) in 1872 and 1897; and in 1906 F. G. Gunnis wrote that it was increasing at Brora (*Journ. cit.*, 1906, 185). In Caithness, Lillie, a correspondent of Evans's, informed him that he has never seen a hedgehog, but "there have been stories of persons finding them," and "they are sometimes taken to Caithness from other districts as pets, and may possibly have sometimes escaped." Bruce, however, on the authority of MacNicol, states that five have been taken in the parish of Reay within the four or five years preceding 1907. There are also a few records from other mountainous districts, as East Ross and the adjoining parts of Inverness, where the animal was said to be plentiful in one of the wilder and less frequented glens in 1893 (Harvie-Brown and Buckley); West Ross, where it first appeared in 1890 [and is supposed to have been imported in bales of hay!] (Hinxman and Eagle Clarke, *Journ. cit.*, 1903, 70); Argyll (Boyd Watt, *Journ. cit.*, 1901, 233-234; J. M. Campbell, *Journ. cit.*, 1902, 50; and Godfrey, 117); and the Dumbarton side of Loch Long, in 1900 (Evans, *in lit.*).

From the **Scottish islands** it is as a rule absent; but it appears in Mull vermin lists of 1825 at a reward of threepence per head (MacLaine of Lochbuie, *Journ. cit.*, 1895, 193); it is common in Bute (Colquhoun, *Sporting Days*, 101; also Boyd Watt), and has been trapped in the Mull of Kintyre (Harvie-Brown and Buckley). It has been introduced at Loch Tingwall, near Lerwick, Shetland (Millais), as well as in the Orkneys; in the latter it has not been since heard of (Harvie-Brown and Buckley); in the Shetlands it has been found near Cunningsburg, Mossbank and Loch Spiggie, Weisdale and Dale in Delting (Buckley and Evans, *Fauna of Shetland*, 1899, 57). Ussher found the bleached leg of one at a peregrine's plucking place on the South Saltee Island, co. Wexford, **Ireland** (*Zoologist*, 1886, 96). It occurs in **Jersey** and **Guernsey**, but in each case is said to have " been introduced " (Sinel).

Distribution in time:—This species is at least of pleistocene age in Britain, although the records are not always clear; witness Macpherson's allusions to remains found in the fissures of Helsfel, near Kendal. Andrews identified its bones from the debris of the neolithic lake-village at Glastonbury, Somerset (*Ibis*, 1899, 358), where it was a contemporary of *Pelecanus crispus*, and Jackson has lately obtained a single left upper molar from the cave-earth of Dog Holes, Warton Crags, Lancashire, a deposit of late pleistocene age (*Lancashire Naturalist*, 1910, 326). Leith Adams's record from Ballynamintra Cave, Co. Waterford, Ireland (*Trans. Roy. Dublin Soc.*, 2, i., 206, 1881), is stated by Scharff to have been an error. The latter's description of Ussher's collections from the Edenvale, Newhall and Barntick Caves of Co. Clare, Ireland (*Trans. Roy. Irish Academy*, Feb. 1906, i., 52, 64), are therefore very welcome. In these, hedgehog bones are present in abundance, mostly from the upper and more recent strata, but their position proves nothing, since their appearance was ancient and the superficial stratum of Newhall Cave contained remains of such extinct animals as the Gigantic Irish Deer, Reindeer, Banded Lemming, Bear, and Arctic Fox. Fortunately one distinct " find " hails from the lower stratum of Newhall Cave, thus placing the pleistocene age of the Hedgehog in Ireland also beyond doubt.

The **period of gestation** is probably seven weeks (Lilljeborg).

The **rutting season** is evidently early, since the **young**, the number of which, although usually about four, may reach eight, have been found in April. A second litter sometimes appears between the middle of August and the end of September (see also p. 73).

The **droppings** are sometimes very abundant, but are not always easy to see except in places where there is no growing vegetation to hide them. They are very distinct in form and texture, of a pointed oblong shape, and a dry, loose texture very different from the strongly cemented droppings of rats or bats, and easily fall to pieces. Fragments of the elytra of beetles are generally conspicuous amongst them.[1] They are not specially odoriferous, but, in the case of captive animals at least, give off a peculiar semi-sweet stink, which is rather stronger than that emitted in the case of carnivores of a similar size.

Description:—The general form and appearance of the Hedgehog are typically those of its genus. It is a thick, stumpy animal, with neck and body shorter in proportion to its bulk than any other British mammal.

The **head** is conical; the ear short, broad, and rounded (Plate V., Fig. 3); the eye prominent; the legs short, bringing the animal's body nearly in contact with the ground when running; the tail a mere stump (Plate V., Fig. 4).

The **hands and feet** have each five toes, all armed with claws, and five pads. Of these, one lies at the base of the second digit, one at the bases of the third and fourth, and one at the base of the fifth. A pair of unequal size lie side by side behind these. The hand is well shown in Plate V., Fig. 1, and needs no further description. The foot is peculiar in the proportion of the digits (Plate V., Fig. 2). No. 1 is short, with a feeble claw; Nos. 2 and 3 are about of equal length, with strong claws, especially the former; No. 4 is shorter and has a smaller claw; No. 5 resembles No. 1, being quite short and with a feeble claw.

The **fur** is harsh and brittle, and is confined to the under surface, except the snout, forehead, cheeks, ears—and, sparsely, the tail. The rest of the body is thickly covered by spines.

The **spines** are arranged in radiating groups, and their most natural position is nearly flat upon the body, but they may be erected at will. They reach a length of about 20 mm., are sharply pointed, hard of texture, with, peripherally, 22 to 24 longitudinal grooves. Each is fixed in the skin by a hemispherical root, above which is a narrow neck bent almost at right angles. Perfect specimens can thus only with difficulty be pulled out from a living animal. On the other hand, pressure or violence applied to the tips is not expended in driving the spines into the body, but in bending the neck, a fact which explains why the animal has no fear of dropping on its back from a height (see Carlier, *Journ. Anat. and Phys.*, xxvii., new series, vii., 1893; and, for a popular figure, Knapp, *Journal of a Naturalist*, ed. ii., 1829, 139).

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[1] "It appears, by the dung that they drop upon the turf, that beetles are no inconsiderable part of their food."—Gilbert White, Letter xxvii. to Thomas Pennant, 22nd February 1770. For much information on this subject I am indebted to Cocks and Moffat.

The spines are annulated with an alternation of dark brown or nearly black and white bands, usually three in number, of which the central is dark, leaving the two ends of the spine light. A small dark tip may or may not be present.

The haired surfaces vary in **colour** from dirty brown to dirty white, without discernible pattern. The variation is due to the proportions of hairs of these two colours. The majority of individuals are altogether brown, but in others the whitish hairs are numerous. Two small and very light skins in the British Museum were obtained by Ogilvie-Grant in Elgin, Scotland. In these the under side and nose are nearly white, with the exception of a dark, not very well defined breast patch and traces of a mid-ventral darkening.

The young, of which Gilbert White (Letter xxvii. to Pennant) noted that they have the eyes closed at birth, the spines white, soft, and flexible, and little hanging ears, are at first quite helpless. Patterson (*Irish Naturalist*, 1901, 254) describes an Irish litter, of which the individuals weighed ·75 oz. (nearly 21 grms.) and measured 2·5 inches (63·5 mm.) in total length. The ears hung down slightly, and the snouts were short, broad, and unlike those of the adults. The soft, white, very small spines lay close down to the back. There were sharp and well-developed claws on all four feet, but no trace of hair on any part of the body. A deep, narrow groove ran down the centre of the back from head to tail. The colour was grey-blue above, fleshy beneath, the head being fleshy and the nose tipped with grey.

I find no trace of **moult** or **seasonal variation**, and it is not known whether the spines, which are, physiologically, modified hairs,[1] are under normal circumstances shed or renewed. Old spines lose the distinct pattern of their grooving, and their roots, which are quite deep when young, approach the surface (Carlier), when they could easily be thrown off and replaced by new ones; and this suggestion is supported by the fact that Cocks finds stray shed spines in his cages. An instance is on record where a hedgehog confined in a garden shed its spines in mid-winter (Ellen Newman, *Field*, 24th March 1906, 442). It was sent to the editor of the *Field* (*Journ. cit.*, 31st March 1906, 519), and eventually to the Museum of the Royal College of Surgeons, London. As an abnormality, the spines may be absent and replaced by hairs (see Cozens, *Journ. cit.*, 17th March 1906, 433; Fritsch, *Natural Science*, xiii., 156, plate ii., 1898).

In connection with the peculiarly helpless nature of the animal, especially during hibernation, Carlier's remarks on the **skin** are of great interest. On the upper surface it is very thick and provided with dense subepidermic tissue, but is poorly supplied with blood-vessels and without sebaceous and sweat glands. The thickness is no doubt a means of protection, and prevents loss of heat by radiation during hibernation. The skin of the ventral surface is, on the other hand, highly vascular and resembles that of other mammals. Much fat may accumulate on the back, especially in autumn.

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[1] Compare: "One must regard as a kind of hair such prickly hairs as hedgehogs and porcupines carry"—Aristotle, *Historia Animalium*, ed. Thompson, 1910, I. 6, 490*b*, 28.

In the **skull** the palate bones have two large unossified spaces, situated in front of a transverse ridge just behind the posterior molars; the pterygoid fossæ are very broad; there is no alisphenoid canal; the mesopterygoid is deep and leads posteriorly into a deep hemispherical excavation lying between the auditory bullæ. The sagittal crest may be well developed in specimens so young that the permanent dentition is only just appearing.

The shape and extent of the premaxillary frontal processes are subject to much variation. In many specimens they are conspicuous, extending backwards for more than half the length of the nasals and with their posterior terminations not sharp or pointed, but blunt or square. This character was at one time supposed to be constant and of subspecific value in British specimens, and upon it was based the description of *E. europæus occidentalis.* Examination of a larger series shows that this is not always the case (see Lönnberg, *Ann. and Mag. Nat. Hist.*, June 1900, 542), but the question cannot yet be regarded as decided.

Some of the **teeth** are quite variable in size, especially the second upper incisor and central upper premolar, the former a point of importance because the lesser dimensions of this tooth were fixed upon by de Winton (*Proc. Zool. Soc.* (London), 1897, 955-956) as diagnostic of *E. algirus.* Although usually far larger in *E. europæus*, this tooth may be occasionally quite small. The central upper premolar is sometimes absent or crowded out of the tooth-line. As regards roots, Hollis (*Zoologist*, 1910, 325-6), examining eleven specimens, found the third upper incisor invariably single, the upper canine six times double, once single, and four times intermediate, *i.e.*, single but with indications of fusion of two roots.

In the upper jaw the central incisors are long and robust, separated and distant throughout their length, their points slightly converging; the second and third pair, particularly the second, are small and conical, resembling premolars. There is a space between the third and the canine, both of which are usually stated to have single roots, but are very variable in this respect. Of the three premolars, the first two are smaller than the third, which has three roots, and an anterior outer cusp so very large as to resemble the carnassial tooth of a carnivore. The first two molars are large, nearly quadrate, and furnished with strong acute tubercles; the first molar is the largest of all the upper teeth, the third is small, placed obliquely, and has to some extent a cutting edge.

In the lower jaw the central incisors, which in shape and size resemble those of the upper, are directed nearly horizontally forwards. There follow three small teeth, obliquely cusped, the second of which is the canine, the third a premolar. Following these, but separated by an interval, is another premolar, a prominent but narrow tooth of height equal or superior to that of the molars; it carries externally two principal cusps and an inner rudimentary one. To it succeed the three molars; the first, the largest of all the lower teeth, has five well-marked cusps; the second is smaller, with four sharp cusps and an anterior rudimentary one; the third is smallest, with one pointed inner posterior cusp, and two rudimentary.

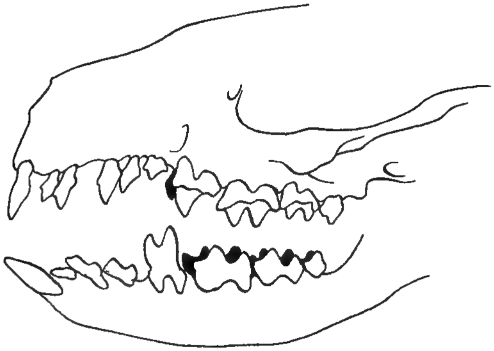

FIG. 22.—SIDE VIEW (diagrammatic and magnified 1½ times) OF TEETH OF *Erinaceus europæus.*

Individual colour variation runs mainly in the direction of albinism, of which, partial or complete, a number of instances are on record[1] (see Spicer, *Zoologist*, 1858, 6058; Bainbridge, *Field*, 13th April 1861, 313; Harding, *Zoologist*, 1879, 172; Maud Stevenson, *Field*, 29th September 1888, 476; Evans, *Journ. cit.*, 6th October 1888, 509; Allenby, *Journ. cit.*, 9th November 1889, 667, and 19th April 1890, 587; Hardbottle, *Zoologist*, 1895, 346-347, and *Field*, 7th September, 1895, 439; W. J. Clarke, *Zoologist*, 1903, 387; Reid, *Field*, 19th December 1908, 1103; and many others). Details are, as usual in such cases, seldom given, but in one instance the sex is said to have been female (Prior, *Zoologist*, 1879, 172); in another, a mother and at least one of her young were albinos (exhibition by Earl of Haddington, *Proc. Nat. Hist. Soc.* (Glasgow), iv., 37, 1878-1880). A true albino recorded by Chapman (*Field*, 15th August 1903, 327) is stated to have been little more than half grown, but I suspect that some of the juvenile albinos recorded were merely very young ones in which the pigmentation of the spines had not yet made its appearance. A family of milk-white hedgehogs in Charles Waterton's park at Walton Hall (*Zoologist*, 1866, 195; see also "Tye (Horsham)" = Bainbridge, *Field*, 16th August 1862, 161) are stated to have been nearly full grown; their mother was of normal coloration. In one case a hedgehog having white spines was dissected, when the nerves connected with the subcutaneous muscles were stated to have been much diseased (Harper, *Zoologist*, 1851, 3022-3023).

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[1] Millais has seen about twenty specimens.

Geographical variation manifests itself in colour, and, as regards the skull, in the shape of the frontal processes of the premaxillæ. My conclusions on the latter point have, however, as has been stated above, been disputed by Lönnberg; but it should be remembered that they were true for the series of specimens at that time in the British Museum, and they may be reinstated when a really satisfactory series becomes available for examination. Southern specimens tend to become white, the extreme being represented by my *E. e. hispanicus* of south Spain, a form with inconspicuous frontal processes to the premaxillæ. My *E. e. italicus* of Italy is not so pale, and in skull agrees with the typical form of Skandinavia, in which the above processes are sharply pointed. My *E. e. consolei* of Sicily has long thin bristles with broad, white, strongly contrasted, dusky annulations. *E. e. concolor* (Martin) from Trebizond and Mount Lebanon is externally very similar, but may be distinguished by its smaller teeth and skull. I have not examined *E. e. transcaucasicus* of Satunin.

During **hibernation** some remarkable changes take place in the tissues, as described by Carlier (*op. cit.*, *vide supra*, p. 51). That they are all altered in constitution, is shown by their being less readily acted upon by staining agents than when the animal is active.

At the commencement of hibernation the blood undergoes a profound change, the number of white corpuscles dropping suddenly from about 20,000 or 18,000 to 3000 or even 1000 per cubic millimetre. At this time the white corpuscles seem to invade the connective tissue of the mucous and submucous coats of the intestinal tracts. Their probable function is to devour the bacteria, which, as Bouchard ("Essai d'une théorie de l'infection," *Proc. Tenth Medical Congress*, Berlin, 1890) has shown, pass from the alimentary canal through the tissues into the blood of an animal which is cooled or chilled. Their work is soon accomplished, and they degenerate and are removed. The blood then slowly but surely acquires its normal proportion of corpuscles.

The lymph-glands also undergo important changes, probably with a view to cleansing the lymph-stream from impurities tending to accumulate during hibernation.

A special bilateral organ, the hibernating gland, lobulated in shape and orange-brown in colour, is situated chiefly in the axillary, cervical, and dorsal regions. Apart from differences due to age or nutrition, it varies greatly in size at different seasons of the year. It is most voluminous in October, and at that time equals about 3·04 per cent. of the animal's total weight. During the early part of hibernation it rapidly diminishes, and at the beginning of January is only about 1·5 per cent. of the total weight, or, allowing for loss of weight by the whole animal, only ·33 of its own original weight. By the end of March it is only ·9 per cent. of the total weight; and, continuing to atrophy, is by June reduced to a few fibrous cords. Thenceforward it increases until the commencement of the next hibernation.

This gland probably acts as a storehouse for fat, which accumulates in it so long as the animal feeds. During hibernation it gives up the fat and probably becomes transformed, a few cells at a time, into highly nutritive matter, fat alone being not sufficient to sustain life.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear.
MALES.				
1.* Louth, Lincolnshire, 14th October 1910	210	35	42	35
2.* Do. do. (undated)	258	34	48	32
3.* Tetbury, Gloucestershire, 11th November 1910	188	22	40	29
4.* Do. do. (undated)	220	24	42	28
5. Cardiff, Wales, 26th May 1899 (R. Drane; Brit. Mus. Nat. Hist.)	263	20	43	22
6. Innerwick, Haddington, Scotland, 8th April 1899 (W. Eagle Clarke; Brit. Mus. Nat. Hist.; type of subspecies *occidentalis*)	218	17	42	28
7. Ennis, Co. Clare, Ireland, 21st September 1893 (T. W. Scott; Brit. Mus. Nat. Hist.)	252	30	40	..
Approximate average of seven adult males, as above	230	26	42·5	29 (6 items)
FEMALES.				
1.* Louth, Lincolnshire, 14th October 1910	194	20	37	31
2.* Do. do. (undated)	232	24	42	30
3. Oundle, Northamptonshire, 20th November 1900 (Brit. Mus. Nat. Hist.)	257	31	40	26
4.* Richmond, Surrey, 10th December 1910	195	18	39	25
5.* Do. do. (same date)	217	30	36	26
6.* Tetbury, Gloucestershire, 11th December 1910	207	28	36	29
7.* Do. do. (undated)	230	24	41	29
8. Exeter, Devon, 21st September 1907 (E. Hollis)	212	21	37	20
9. Topham, do. 8th October 1907 (E. Hollis)	232	21	38	22
10. Cardiff, Wales, 26th May 1899 (Brit. Mus. Nat. Hist.)	194	17	34	24
11. Immature, Hardington, Gloucestershire, 15th Nov. 1894 (R. Hooper; Brit. Mus. Nat. Hist.)	179	23	35	21
Approximate average of ten adult females, as above	217	23·5	38	26

* Measured by T. V. Sherrin, to whom I am indebted for particulars.

The table suggests that males are larger than females; see also the weights given below.

Skull:—Greatest length, 55 to 57; basal length in middle line, 53 to 57; palatal length in middle line, 42 to 43; length of upper tooth-series, 28 to 29; same in lower jaw, to tip of incisor, 26; greatest breadth

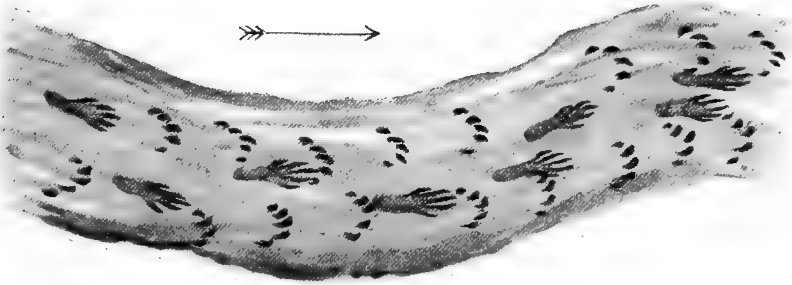

DIAGRAM OF MOLE'S TRACKS IN SNOW. (Reduced; after Adams.)

The tracks made by the hind feet are shown as elongated marks nearer the centre, those of the fore feet as semicircular impressions nearer the margin of the diagram.

These tracks were illustrated, but with less detail, by the late Mrs Eliza Brightwen in *More About Wild Nature*, 1892, 117.

at zygoma, 34 to 36; posterior breadth, 31; breadth between orbits, 17 to 18; breadth at constriction, 14 to 15.

Weight:—The Hedgehog, being a hibernating animal, probably varies considerably in weight at different seasons of the year, being theoretically heaviest just before and lightest some time during hibernation. Although this is probably true, there are no detailed supporting observations. Webb's results (*Zoologist*, 1876, 4824-4825) were vitiated by the fact that the Irish pair which he weighed at weekly intervals throughout the year lived in the partial confinement of a garden, and were fed on bread and milk in winter. He found that the male was nearly always heavier than the female, especially in May and June; he reached his maximum of 2 lbs. 7 oz. in the third week of May, and dropped to his lightest in December and January (1 lb. 7·5 oz. to 1 lb. 8·5 oz.). The female seemed to follow a different cycle, since, although also lightest in December and January (1 lb. 6 oz. to 1 lb. 7·5 oz.), the heaviest weight she reached (1 lb. 15·5 oz.) was in the last week of October, in which week and the previous one, she—for the sole time in the year—was slightly heavier than the male. It would be interesting to correlate the variation in weight with the accumulation of fat, supposed to be greatest in autumn just before hibernation, at which time Webb's male specimen was steadily losing weight. The extremes of weight, running from 1 lb. 6 oz. to 1 lb. 15·5 oz. in the female, and from 1 lb. 7·5 oz. to 2 lbs. 7 oz. in the male, agree with such isolated records as I have been able to inspect; but the experiment needs confirmation with wild animals, great care being taken that the results should not be upset by irregular feeding.

Wadham writes me that he examined a very large Isle of Wight specimen; the weight was 3 lbs. 8 oz., so that it appears to have been an exceptionally heavy animal.

Although at first sight deprived by its structure of all means of attacking its enemies, of defending itself by force, or of seeking safety in flight, this animal is yet endowed with a tolerably effective safeguard in its close covering of sharp spines. These being hard without being brittle, sufficiently elastic to bear great violence without breaking, and fixed with astonishing firmness in the tough leathery skin, form not only a solid shield-like protection from the effect of blows or falls, but a shirt of prickly mail sufficiently sharp and annoying to deter all but the most resolute of dogs from venturing an attack. The moment a hedgehog is touched, or perceives danger approaching, it rolls itself up into a compact round ball, by the contraction of the powerful fibres of the panniculus carnosus muscle which covers the body immediately under the skin; and thus it presents to its enemy an impenetrable panoply, beset by innumerable spines standing out in every direction. The more it is irritated or alarmed, the more firmly it contracts, and the more strongly and stiffly the spines are set; and its appearance at such times did not escape the eye of Shakespeare, who put the following into the mouth of Caliban:—

> "Then like hedgehogs, which
> Lie tumbling in my barefoot way, and mount
> Their pricks at my footfall."
> —*The Tempest*, Act ii., scene 2, line 10.

Bell, remarking on the strength and elasticity of this covering, states that he repeatedly saw a domesticated hedgehog run to the wall of an area, and, without hesitation, throw itself over. Contracted into a ball, it fell twelve or fourteen feet, and, immediately afterwards unrolling, ran off unhurt.[1]

The assertion of Pliny,[2] followed by his numerous plagiarists, that the means of defence just described are aided by another of a very different character—the expulsion of the urine, in such a manner that it spreads itself over the whole surface of the skin, and by its odour disgusts and repels an assailant—is doubtless based upon the incontinence of the terrified animals. But it may also have reference, as suggested to me by Mr C. B. Moffat from actual experience in this direction, to a genuine, but not invariably used power of emitting an unpleasant smell under the influence of fright. By the Romans this assertion was doubtless read with reference to a different object—namely, the supposed rendering useless by this defence of the prickly skin, which they used in hackling hemp for the weaving of cloth. Apart, however, from its own unsavouriness, the numerous fleas and other parasites which often make the Hedgehog their host render its examination at close quarters far from pleasant.

The suggestion advanced above, that the Hedgehog is capable of emitting an unpleasant smell under the influence of fright, will probably be regarded as controversial. It is so interesting, that Mr Moffat's observations may be given in detail in the hope that further evidence, corroboratory or the reverse, may be forthcoming. The animal is not usually regarded as particularly odoriferous, and its presence may not appeal directly to human nostrils; but there can be no doubt that it does possess a peculiar, definite, and comparatively strong odour, which is so unmistakable that dogs can be readily trained to hunt for it.[1] The possession of a peculiar and unpleasant odour by an animal which is at the same time palatable, painful to handle, and easy to see or find in the open at night, would be a natural combination of characters already shown by Mr Pocock to occur in the somewhat similarly equipped porcupines,[2] in which, however, it is accompanied by even more conspicuous coloration.

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[1] And this observation has often been since confirmed, as by R. I. Pocock, who writes me that he has often seen hedgehogs, in dropping from a table, slightly slide off, turning in the air, so as to alight back downwards on the floor. See also below, page 71.

[2] viii., xxxvii.

Mr Moffat's experience was obtained by putting a hedgehog into a water-butt for the purpose of seeing it swim. Immediately on finding itself in the water, the animal emitted an effluvium so powerful that he had to run back five or six yards to find an atmosphere in which he could breathe. "It was quite an unpleasant work," he writes, "afterwards to release the poor creature from its swimming-bath. . . ." He adds that he is not morbidly sensitive to odours, but the result of his experiment as related above beat anything on the part of a live animal that he ever encountered before or since. Mr Moffat subsequently gave another hedgehog a bath to see if it also would act skunk, but he was disappointed to find that it did not. But his previous experience is partially borne out by his observation that a fairly strong odour is sometimes produced when hedgehogs are fighting at night, but this is "nothing whatever" to the stench made by the animal that he put into water.

It looks as if the animal's general behavour is guided by its protective coat of prickles, or, as Mr Moffat puts it, that it trusts a good deal in its own comparative immunity from attack. Thus Mr Moffat finds that when moving about by night it does advertise its presence by sounds, making a furious sniffing with its nostrils, and also rustling among the leaves and herbage in a way that no other small animal could do without great unwisdom. "One can easily track Hedgehogs—I think from a distance of 40 yards—by the perpetual noise they thus keep up, which tells us both *where* they are and *what* they are."

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[1] As pointed out by many writers; see Knapp, *Journal of a Naturalist*, ed. 2. 1829, 135; also, Sir William Jardine's *Supplementary Notes* to Jesse's edition of White's *Selborne*, 1854, 404-5. It is "A peculiar, frousty, semi-sweet smell, which also clings to the droppings."—Cocks, *in lit.*

[2] Of the genus *Hystrix;* see *Proc. Zool. Soc.* (London), 1906, 902, published April 1907, also 1908, 946, published April 1909; and *Field*, 11th March 1911, 489.

Enough has been written above to suggest that the Hedgehog possesses the attributes both of smelling and self-advertising, but it would be desirable that further observations should be made on so interesting a subject. Some exotic hedgehogs are evidently further advanced on the same path, for their tints are brighter and more nearly approach the category of "warning coloration," and, according to Captain T. Hutton,[1] an Indian species[2] makes a grunting sound when irritated, and when touched suddenly, jerks up its back so as to throw its spines forward, making at the same time a noise like a puff from a pair of bellows. This action at once brings it into the same category as a porcupine.

Whatever may be thought of the above conclusions, two facts are incontrovertible—viz., firstly, that the Hedgehog is a palatable beast, acceptable, apart from sentimental prejudices, both to man and to carnivorous animals; and secondly, that despite its prickly armour, many animals eat it, especially when it is young and lacks the defence of the adult's spines. This does not mean that the prickles are not protective, but merely that they can be overcome by an enemy which is so hungry that it will put up with wounds so long as it obtains a meal. Even so, the effect of the prickles is to make carnivorous animals think twice before attacking a hedgehog, and thus to cause them to seek other food first.

The flesh is eaten by men in some parts of continental Europe, where the human dietary is wider than in Britain. But even in this country it must have been at one time considered a delicacy by the cultured, since "hyrchouns"[3] were served at a feast in 1425.

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[1] In W. T. Blanford. [2] *E. collaris* of Gray and Hardwicke.

[3] See F. J. Stubbs, *Zoologist*, 1910, 155.

It is still eagerly sought after by gypsies and others,[1] who are very fond of it, but the few refined people who have tried it give very contradictory accounts of its quality. Probably the objections are due to prejudice, for Mr Pocock writes me that he knows hedgehogs to be delicious eating, having supped off them in the Balearic Islands; and Mr Owen Jones gives directions[2] for broiling them, taken at first hand from the gypsies; he remarks that you are lucky if you can obtain them in late autumn, for by that time they have encased themselves in fat against the days of their winter sleeping.

It is not at all certain how carnivorous mammals overcome the defensive armour, but there can be no question that they do so at least occasionally. It frequently happens also that a well-trained dog is found bold and active enough to "open" a hedgehog, at the expense of a bloody nose and sorely pricked paws. The siege is often of long duration, and success in some cases probably results rather from relaxation of its guard on the part of the tired victim than from the actual victory of brute force. The smallest grip on the unprotected portions of the body is decisive. A clever plan of campaign is described by Mr J. G. Millais, who once observed a dog kill one of these animals by scratching away with the nails of his fore paws until he had made an entrance large enough to fix one paw against the poor brute's chest. With the other he drew up the head, forced it back, and a nip on the throat finished the tragedy.

The Fox, the Badger,[3] and the Polecat are all credited with the power of despatching the Hedgehog, in the last case on the authority of H. A. Macpherson. He is not, however, very definite, and merely remarks that two of his correspondents found the remains of hedgehogs in the Foumart's larder; but Mr A. H. Cocks finds that captive polecats will consume even the prickly skin, devouring the bristles clean from within. In any case, there can be no doubt that both foxes and badgers eat hedgehogs, both dead and alive, although, finding young ones easier to kill, they probably attack adults only when they are very hungry. In overcoming the prickly armour, Mr Millais thinks that foxes may possibly use the tactics so successfully pursued by the dog which came under his observation, as already described.[1] Colonel J. S. Talbot writes me, however, that the method employed is to seize the prey before it has had time to completely roll itself up, there being always a moment of hesitation following the first alarm.[2]

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[1] As in Essex, *fide* H. Laver, *in lit.*

[2] In *Woodcraft*, 1910, 147; as did F. T. Buckland in *Curiosities of Natural History*, edition of 1879, series 2, 129, etc.; and Millais also, from information supplied by F. H. Groome.

[3] "Few people are aware probably that its chief enemies are the badger and the fox. Where they dwell hedgehogs are not likely to become too numerous."—J. E. Harting, *Vermin of the Farm*, 1892, reprint, 35. There is a remarkable note in the *Field* of 23rd March 1875:—"The pitiful wail of a hedgehog when caught by a badger is not easily forgotten, for although he will curl himself up and be torn to pieces by a terrier without a cry, the moment a badger approaches him he commences the most piteous cries, and death seems long and painful, for the badger sucks the blood before devouring the body."

Mr Moffat tells me that hedgehogs are eaten by rats,[3] but it is sometimes uncertain which party is really the aggressor, since hedgehogs are themselves nothing loth to attack rats, and will certainly do so in captivity, as observed by Mr Pocock. They have been seen to do so by a correspondent of Mr G. A. Passingham's,[4] and instances are on record[5] where they have freed a garden of these rodents. On this point an anecdote of the late J. C. Mansel-Pleydell's[6] is illustrative both of the conflicts which occur between hedgehogs and rats, and of the activity displayed by the former, although apparently so clumsy. He relates that at about eleven o'clock one moonlight night loud cries were heard in the branches of a virginian creeper under the eaves of a house at a height of twenty feet from the ground. The cries gradually came nearer, until a rat and hedgehog fell to the ground together, the latter with visible marks of the rat's teeth upon its body. Mr Lionel E. Adams also sends me an instance of a hedgehog killing a large rat, but the former itself succumbed to its injuries a day or two later.

The above remarks lead to a consideration of the Urchin's carnivorous propensities. These, unfortunately, although often denied by partisan writers, can no longer be glossed over by an impartial historian. The animal has many defenders, but its predilection for eggs, game, and poultry has long stood on record,[1] and is supported by the convincing testimony of a host of recent accusers. Details of its exact delinquencies, although some account of its methods of feeding and hunting may be acceptable, would therefore seem to be superfluous. It may be remarked in its favour that its attentions to eggs may in the first instance arise from a love of warmth rather than from malice prepense. An outlying barndoor hen has been found sitting on her uninjured eggs with a hedgehog's prickly body interposed between her and them![2] No doubt, however, the first breaking of an egg would give the hedgehog, at first innocent, a guilty knowledge of their nature; and the presence of the unwelcome intruder in a pheasant's or partridge's nest can be scarcely more conducive to successful hatching than if it destroyed the clutch wilfully and without hesitation.[3]

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[1] For the Hedgehog's sake it is to be hoped that the plan adopted is not that detailed by Topsel, the nature of which prevents its repetition here.

[2] See also article on *Fox*.

[3] See also, for a description of such an encounter, G. C. Green, *Field*, 9th January 1892, 35.

[4] *Field*, 30th November 1895, 903.

[5] Lord Lilford, *Zoologist*, 1890, 453.

[6] *Field*, 16th November 1895, 827.

But, in spite of all that has been said, it is correct to write that its usual aliment consists of beetles, worms, slugs, snails, and various other insects and invertebrates, in search of which it is fond of grubbing in cow-dung.

Its fondness for insects makes it a useful pet in the basements of houses where such pests abound, and, were it to restrict its operations to the pursuit of such small game, there is no doubt that it might be set down as a creature useful to the farmer and harmless to the game-preserver. In the neighbourhood of big cities, in market-gardens and pasture-lands, its presence may be entirely beneficial.

But the changed conditions brought about by game, the extermination of the carnivorous mammals, and the increase in numbers of helpless game-birds and their eggs, have forced the Hedgehog into a position which it might not otherwise have occupied. Its numbers become excessive, and its dietary consequently enlarged, until it starts poaching and falls under the bann of extermination.

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[1] See, for instance, Rev. J. C. Atkinson, in *Zoologist*, 1844, 791; several other letters on the same subject in the *Zoologist* were collected in *Letters of Rusticus*, 1849, 111-115.

[2] M. S. Young, *Nature Notes*, 1901, 16-17.

[3] Many individuals seem never to have learnt the nature of the contents of large eggs, and in captivity do not know how to reach them until the shell has been broken (see Atkinson, *loc. cit. supra*). Few, if any, mammals, even if otherwise confirmed egg-eaters, recognise cold fresh eggs as eatable, although they will devour them freely when warm, especially if containing a nearly hatched chick. But the five captive hedgehogs of which R. Drane writes me that, even when hungry, they refused eggs, whole or broken, boiled or fresh, must have surely been exceptional.

It has often been stated that hedgehogs will eat many vegetable substances, including succulent leaves such as those of the dandelion and lettuce.[1] But Mr Cocks informs me that a pair in his possession could not be induced to touch raw vegetables, and it seems likely that such substances would not be highly relished by such a confirmed animal-eater.

Its recorded dietary is, however, a wide one, and is said to include acorns, wild fruits, apples, swede turnips, toadstools, bees[2] (honey[3] or bumble) and wasps[4] (which it has been found eating at their nests or hives), frogs,[5] young or wounded birds, mice, and, when they can be secured, rats and rabbits. All sorts of offal attract it, and it falls a victim to baits, such as entrails and flesh or bread and aniseed, intended for the destruction of other very different animals.

It has been accused of seizing a hare by the hind leg.[6] In fact, it will eat any living creature which it can overpower, and almost any dead one. That it will devour even snakes when opportunity offers, may be taken for granted. But that such a practice is habitual to it may well be doubted, most so-called experiments[1] having merely shown that when the two animals are confined in a box together the ensuing conflict provides the urchin with its supper. There is usually nothing to show that the conflict was desired by either of the combatants. The hedgehog's plan of campaign is to snap quickly, and then instantaneously to present its armoured back to the reptile, which, if poisonous, beats itself to death against the erect spines. This has been observed by several naturalists, as, for instance, by Mr Harting,[2] in the case of captive specimens,[3] and also by Richard Kearton,[4] who watched one kill a slow-worm with similar precautions. Mr Pocock also informs me that the same procedure was adopted on one occasion in the case of a rat, the hedgehog approaching the rodent sideways and keeping its spines directed towards it.

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[1] In Cyprus the Long-eared Hedgehog, *Hemiechinus auritus*, feeds on grapes, and the Cretan representative of our own species will eat oats; see Miss D. M. Bate, *Proc. Zool. Soc.* (London), published 1st April 1904, 343, and 5th April 1906, 317. Gilbert White's statement that hedgehogs "eat the roots of the plaintain in my grass-walks" (Letter xxvii. to Thomas Pennant), has been shown to have been an error, the damage having been the work of a caterpillar (see *Letters of Rusticus* 1849, 110-115).

[2] W. D. Crotch, *Zoologist*, 1850, 2637

[3] William Storey, *Mammals of Upper Nidderdale*, 1885, 195.

[4] Max Peacock, *Naturalist*, 1st October 1900, 320.

[5] Toads have also been included, but probably in error. Cocks cannot induce any mammals to eat them in captivity: but Pocock writes me that he has seen a tame white rat lapping the blood of a toad which it had wounded. No doubt, but for his intervention, the rat would have killed the toad.

[6] M. A. Matthew, *Zoologist*, 1887, 233; and William Thompson quotes the *Gardener's Chronicle*, 1846, 480, for an assault upon a leveret.

The battles of hedgehogs and snakes have been recounted with more or less embellishment by many authorities from ancient times. Topsel's version has at least the virtue of picturesqueness, and on that account alone deserves quoting.

"There is," writes Topsel, "mortal hatred betwixt the Serpent and the Hedge-hog, the Serpent seeketh out the Hedge-hog's den, and falleth upon her to kill her, the Hedge-hog draweth it self up together round like a foot-ball, so that nothing appeareth on her but her thorny prickles; whereat the Serpent biteth in vain, for the more she laboureth to annoy the Hedge-hog, the more she is wounded and harmeth herself, yet notwithstanding the height of her minde, and hate of her heart, doth not suffer her to let go her hold, till one or both parties be destroyed.

"The Hedge-hog rowleth upon the Serpent, piercing his skin and flesh, (yea many times tearing the flesh from the bones) whereby he scapeth alive and killeth his adversary, carrying the flesh upon his spears, like an honourable banner won from his adversary in the field."

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[1] As of Rev. William Buckland, see W. J. Broderip, *Zoological Journal*, ii., v., 19, published April 1825; also of F. T. Buckland, *op. cit.*, edition of 1879, series 2, 132.

[2] There is a translation of a French version in *Zoologist*, 1887, 306; and Harting refers me to *Le Chasseur François* (*St Etienne*), 1st June 1898, and to *Chasse et Pêche*, (Brussels), 24th June 1894, for other recent accounts, but I have been unable to see either journal.

[3] *Vermin of the Farm*, 1892, reprint, 33.

[4] *The Fairyland of Living Things*, 1907, 95.

Before leaving this question it may be well to direct attention to the Urchin's apparent immunity to snake poison.[1] But it is in other respects also abnormal, being in my experience difficult to drown, and it has the reputation of being proof against many poisons.

Hedgehogs are dirty feeders, writes Alston,[2] whose account of the animal is very lively. Like other carnivores, they soil their food and carry parts of it that they cannot eat to their sleeping places, where they are content to repose on a mass of putrifying meat. They lap milk like a dog, but bite sideways in pig-like fashion. The contents of eggs are licked out through a hole in the shell, which is kept constantly enlarged as the requirements of the banquet demand. Portions of the shell may be swallowed, but are not digested. Unlike the weasels, which seize their prey by the back of the head, hedgehogs, like moles, shrews, and rats, attack the abdomen, in order to devour first of all the entrails; if necessary they eat their way into the still-living victim, turning the skin neatly inside out as they proceed. They will crunch the bones of so comparatively large an animal as a mole, but, at least in captivity, seem to be unable to cut the tough skin with their teeth.[3] Alston stated that in eating they smack the lips loudly, and undoubtedly they make what Atkinson called "a singularly harsh sound" over their meals. But this, as Mr Cocks writes me, is probably due to "staccato" chopping movements of the teeth.

The smaller victims are chewed with cruel deliberation. Leonard Jenyns[4] has well described how a worm was seized by one extremity and gradually eaten to the other, and Mr Harting's specimens tore frogs limb from limb.[5] There is some difference of opinion as to the treatment meted out to snails. Mr H. L. Orr[6] writes, for instance, that they are separated from their shells before being swallowed, whereas Mr Moffat declares that they are crunched up, shells and all. The latter adds that he has seen wild hedgehogs eat a black slug of a kind which he believes that most birds reject.[1]

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[1] See G. Physalix and G. Bertrand, *Revue Scientifique*, 8th August 1896, 189.

[2] *Zoologist*, 1866, 58-60; Atkinson's account (*op. cit. supra*) is also excellent.

[3] *Fide* Adams.

[4] *Observations on Natural History*, 1846, 61.

[5] *Op. cit.*

[6] *Irish Naturalist*, 1899, 628.

Most authorities agree in stating that shrew-meat is one of the few possible foods that a hedgehog cannot face. Sir Oswald Mosley[2] stated that one died under his observation within an hour of its having mouthed a shrew's carcase, but it must have owed its death to some other cause. It would hardly have been abroad at noon if in good health. Be that as it may, the late Robert Service threw the strong weight of his testimony into the opposite scale, writing me that he had not the least doubt that the Hedgehog is the principal cause of the mortality which is so well known amongst the shrews at certain seasons. Unfortunately, he was never actually present at such a tragedy, and could not be sure that the supposed victims were ever eaten. It will, therefore, be well to suspend judgment on this point.

Service found that hedgehogs destroy a good many eggs of birds nesting on the ground, especially skylarks, but that the destruction is mainly done on the day or evening before the eggs are due to hatch. He believed that, perhaps, the condition of the eggs is recognised by some peculiarity of smell, since in his experience young birds or fresher eggs were rarely taken.

Hedgehogs are as quarrelsome as other insectivores. Alston[3] remarked that his captives, when fighting, tried to seize each other either by a hind leg or by the unprotected skin of the belly, and Service[4] was much entertained by the encounters of wild ones, apparently all males. On 15th May he found a couple "snuffling" at each other, and they then began a monotonous "mill-wheel walk" with noses opposed. This circling continued for three-quarters of an hour by the watch, and after an absence of twenty minutes they were found sixty yards away, still rolling over and worrying each other as viciously as ever he had seen dogs fighting. Each had hold of the other by a fore paw, and was shaking it as a terrier does a rat, puffing and blowing with the exertion. Sometimes one was uppermost, sometimes the other. An incautious approach ended the fight, and they both scuttled into the bushes. They had been tearing at each other for eight minutes in his sight. Mr Moffat writes me in similar strain, but in his experience the combatants are so cautious as rarely to arrive at close quarters.

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[1] *Irish Naturalist*, 1900, 50.

[2] *Zoologist*, 1854, 4477.

[3] *Zoologist*, 1866, 59.

[4] *Ann. Scott. Nat. Hist.*, 1901, 232-3.

Amongst the ancients the Hedgehog was the subject of many superstitions and prejudices. Not the least curious is that repeated with variations by many authors, and of which Topsel's version runs:—"When he findeth apples or grapes on the earth, he rowleth himself upon them, untill he have filled all his prickles, and then carryeth them home to his den, never bearing above one in his mouth." To this some add the scaling of trees to secure their fruit, and A. R. Forbes quotes the Gaelic legend of the Hedgehog's hoard, or *cnuasachd na gràineag*, signifying that all things gathered in this world must be left at the grave, just as the Hedgehog has to leave its burden of crab-apples at the narrow entrance of its den. Another example of mediæval natural history may be found in a sixteenth-century treatise on riding,[1] by Thomas Blundevill, wherein it is gravely stated that "the shirle (*i.e.*, shrill) crye of a hedgeog strayt teyed by the foote under the Horses tayle, is a remedye of like force" for a jibbing horse.

An ancient belief which still survives in many country districts,[2] namely, that the Urchin sucks the cows during the night, seems at first sight to be in the highest degree improbable, and was accordingly scoffed at by Bell, who has been followed by most modern writers. But in favour of the prosecution it must in fairness be recorded that there exists a definite signed description of the finding of a hedgehog close to a milch goat in weather so warm as almost to preclude the suggestion of its having sought the goat for heat's sake.[3] Again, the late J. H. Gurney (senior) printed the signed statement of a servant who found two hedgehogs sucking a cow.[1] Major John Spicer,[2] an acute observer, commenting on the wide prevalence of the belief in milk-sucking, noticed the Hedgehog's power of stretching out its neck, its love of milk, and the cow's pleasure at being relieved of it, together with a supposed calf-like cry on the part of the Hedgehog, and confessed that he did not "see the great improbability of it." Lastly, Sir Harry Johnston points out that there is nothing improbable in a hedgehog, from merely seeking the neighbourhood of a cow on account of the insects which accompany her, being attracted to lick and finally to suck the nipples. But careful naturalists, remembering amongst other things, the small size of the Hedgehog's mouth, will probably await further evidence before they place the sucking of cows amongst the habitual accomplishments of the animal; and I am inclined to think that the story may be classed with the many other mythical narratives which make the work of the older naturalists more picturesque than trustworthy.

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[1] *A New Book containing the Art of Riding*, published "at the sign of the Hedgehog, St Paul's Churchyard," ed. of 157—.

[2] *E.g.*, Nidderdale, Yorkshire (Storey), and stated by Spicer (*Zoologist*, 1858, 6058) to be very generally believed by the lower orders of the south of England.

[3] A. C. Mackie, *Nature Notes*, 1901, 136.

The crimes of the Hedgehog, supposed or real, have caused this poor animal to be the subject of an unrelenting persecution from time immemorial. It appears in old Churchwardens' Accounts[3] amongst the list of outlaws for whose devoted heads a reward was paid. The price in Westmorland was twopence[4] in the seventeenth century, but in Oxfordshire[5] and Bedfordshire double that amount in the two following. The pursuit, now abandoned by the churchwardens, has been taken up by the gamekeepers, with the result that the animal's numbers in any one district depend chiefly on the success which attend its enemies' efforts to reduce them.

In its natural state the Hedgehog is, with exceptions to be noticed below, almost entirely nocturnal. Its gait is quick and shuffling, and it proceeds, as it were, by starts, not continuing its course for any considerable distance at a time. Constant interruptions occur while the animal halts to smell and snuff, or root a hole amongst the leaves and grass, then as suddenly it jogs along on its quiet way again.[1] Its food is sought chiefly by the sense of scent, which is so keen that Mr William Evans remarks that it will follow up the tracks of a beetle with facility and speed. So engrossed is the animal in its business, that any one who remains moderately still may watch it at work from a distance of a few yards.[2] So fearless is it of the quiet proximity of men, that it has been known to lick an observer's boots,[3] or to thrust its snout under the instep in search of food.[4] But on any suspicious movement the hitherto vivacious Urchin becomes motionless, its head dropping between its fore paws preparatory to subsidence, if need be, into a ball of impenetrable bristles. At times hedgehogs, perhaps when unwell, appear abroad by day, but their diurnal movements frequently coincide with times when food is scarce, such as autumn frosts. The increased number of slugs and snails which come out when a good shower succeeds a summer drought are also no doubt the cause of diurnal appearances.[5]

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[1] On the authority of T. F. Buxton; see *Zoologist*, 1853, 4151-4152. Adams also writes me that he once received somewhat similar and unsolicited testimony from a country boy.

[2] *Loc. cit.*, 6057.

[3] H. A. Macpherson; for Buckinghamshire, see Cocks, *Zoologist*, 1892, 63; for Bedfordshire, J. Steele-Elliott, *Journ. cit.*, 1906, 161-167, 253-265.

[4] Fixed at that amount by Act of Parliament in 1564, 8 Elizabeth (c. 15).

[5] *Fide* Cocks. *Cf.* also Rochdale, Lancashire, 1643—"3 hedge hodgs, 1s. od." (Stubbs, *Zoologist*, 380).

Although at first sight a clumsy and feeble creature, the Hedgehog is in reality possessed of astonishing activity,[6] even in spheres in which it would have been, perhaps, least expected, namely, as a runner, climber,[7] and swimmer. It has no hesitation in ascending to a height, and, provided that the nature of an obstacle is such as to afford it a little assistance, as when the surface of a wall is rough, or there are rain-pipes,[8] fruit trees,[9] or creepers,[10] it will readily make its escape even from enclosed gardens or yards. One which I placed in an enclosure fenced in by two sets of close-meshed netting worked its way in between the two and thus clambered out. It seems to have no fear of falling, and alights on its feet in leaping off a table to the ground, with the air and elasticity of an animal thoroughly accustomed to such performances.[1] It has even been observed to drop five feet down a bank into a river, across which it proceeded to swim.[2] As a swimmer its proficiency at least equals its needs, and it must be at times capable of considerable achievements in this direction.[3] Mr Cocks once knew one to land at Great Marlow after a swim in the Thames, which must have extended, probably down stream, for some hundreds of yards. Mr Millais has drawn one in the water;[4] the animal is immersed deeply, with back, eyes, and snout just above the surface.

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[1] See Rev. A. C. Smith, *Zoologist*, 1853, 4010.

[2] H. J. J. Brydges, *Zoologist*, 1847, 1768. Service has had eight in full view within twenty yards on a summer's evening.

[3] Millais, i., 115-116. [4] *Fide* Moffat. [5] *Ibid.*

[6] Despite its spines it can scratch its own back (Rev. C. A. Bury, *Zoologist*, 1844, 778).

[7] Cocks also writes me that he has often been astonished at the powers of climbing exhibited by captives.

[8] R. H. Scott, *Zoologist*, 1886, 242, from *Nature*.

[9] O. Grabham, *Field*, 3rd December 1898, 897.

[10] Mansel-Pleydell, *Journ. cit.*, 16th November 1895, 827.

In the daytime the Hedgehog retires to a warm, soft nest of moss and leaves, where, rolling itself into a compact ball, it sleeps heavily and with much snoring until the approach of night summons it to the outer world. This nest is usually placed in some covered situation, as in the hollow of a tree decayed at the base, or amongst the naked roots from which the earth has been washed away, in holes of rocks, in a dry hedgerow, or under the brushwood in a coppice. The favourite materials are withered leaves, perhaps because they are effective in keeping out the wet. There is no definite arrangement of the nest, but the animal is well concealed by a coating of leaves, which, becoming perforated by its spines, often remain attached to it after it has left its bed.

The nest is never (in the wild state) encumbered by the stores which provident animals such as rodents lay up for their winter use. Instead, the Hedgehog trusts to hibernation to carry it through the lean months of the year, and then subsists on the thick masses of fat which by the onset of autumn have accumulated in its body.[5] This hibernation, although well known to be extremely irregular in captive animals, had never—in this country—been studied in detail until Mr Moffat[1] undertook the task at Ballyhyland, County Wexford, Ireland. His observations show that the animal is herein no less eccentric than in its appearance and general habits. Watching its haunts regularly throughout a single winter from 26th October to the end of February, he found it abroad on fifteen nights in November, nine in December, four in January, but not at all in February. The hibernation, in so far as it showed a progressive decrease up to February, resembles that of the Pipistrelle, but beyond that point there was no coincidence. The winter appearances of the bats depended entirely on temperature, and they were always active when the weather was mild. On the contrary, there was no evidence that warmth had any effect in waking up the Hedgehog; indeed, it was almost invariably on the cold nights that it was encountered, as if its winter activity was independent of weather. It is noteworthy that, although in December and January bats were observed on nineteen and hedgehogs on thirteen occasions, yet there were only two nights in December and not one in January on which both were seen abroad simultaneously.

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[1] From greater heights it probably alights on its bristles—see above, p. 58, and Atkinson, *op. cit.* Moffat has sent me details of a third method of alighting; he once saw one, before dropping from a height of not more than four feet, spread itself out into "an almost flat" shape, evidently with a view to break the fall.

[2] H. J. Charbonnier.

[3] See Max Peacock, *Naturalist*, 1901, 44.

[4] *The Mammals of Great Britain and Ireland*, vol. i., plate facing p. 112.

[5] A male dissected by Robert Patterson on 15th September had the dorsal fat-layer fully a quarter of an inch thick; see *Irish Naturalist*, 1901, 254. This fat is used by labourers as a salve for rheumatism (Jones, *Woodcraft*, 1910, 101).

Mr Moffat's remarks can only be regarded as conclusive for a single winter and a particular locality. It is clear that the hibernatory habits of an animal having a wide geographical range must vary considerably, and that for the hedgehogs there will be found many variations between the routine of those southern forms which, according to Blanford, never hibernate, and the more northern, the hibernation of which in Germany is described by Blasius as commencing, apparently irrespective of date, only when the temperature drops to 38·75° or 36·5° F., and terminating in March when the temperature of mid-day rises to 54·5° or 59° F.

Evidently extreme eccentricity and uncertainty are the main characteristics of the hibernation of the animal in Ireland, and on this point it is well to remember that Mr Moffat's notes are supported by the recorded observations of other naturalists, who have remarked on its discontinuity[2] and upon the un-

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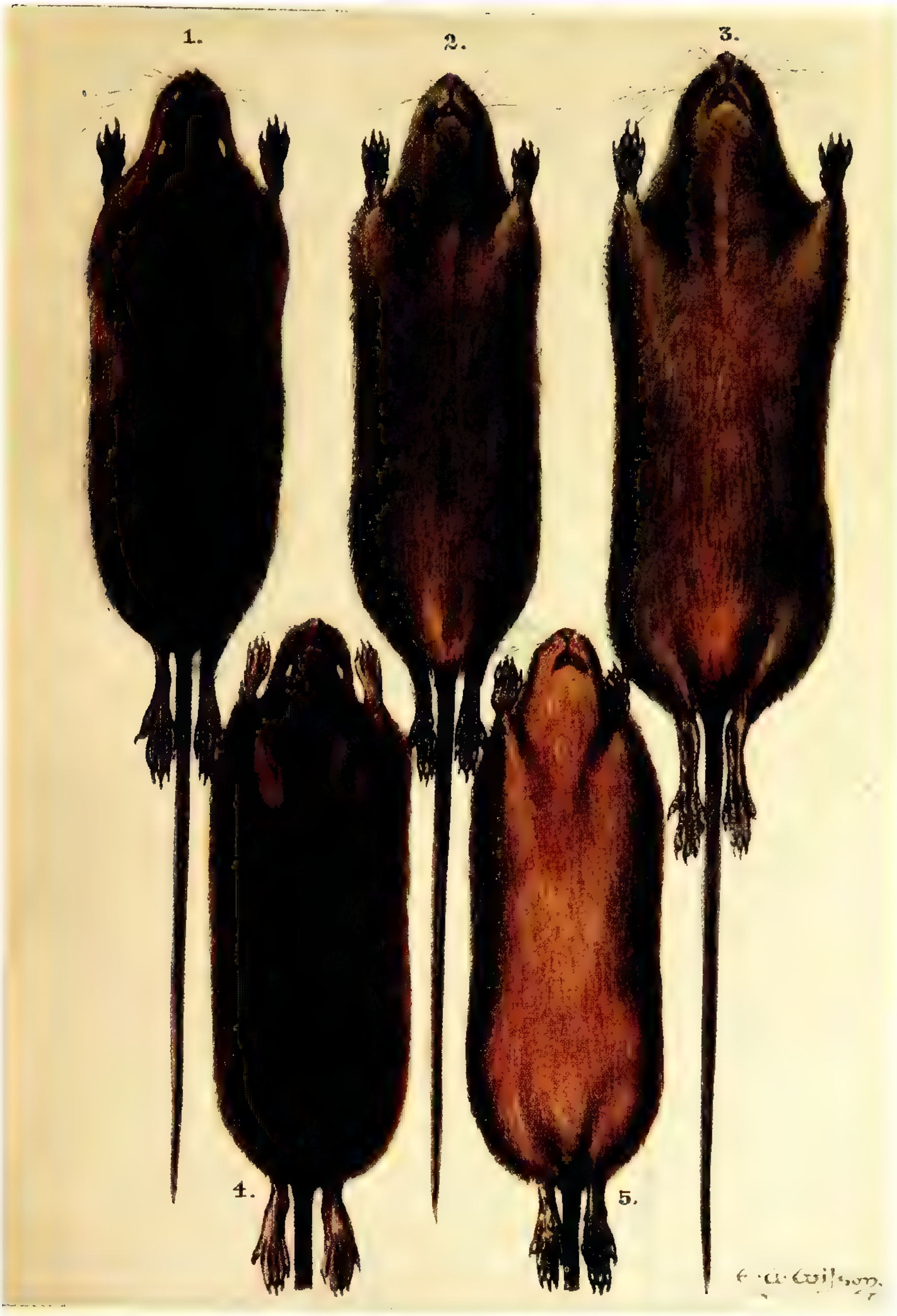
[1] *Irish Naturalist*, 1904, 81-87. Moffat has also sent me some MS. notes supplementing his paper.

[2] Grabham in Yorkshire, *Zoologist*, 1896, 76.


1.
2.
3.
4.
5.
E. A. Wilson.

House Mouse.

expected appearance of the animal in times of frost and snow.[1] They thus confirm Spallanzani's Italian experiment, and in Dumfriesshire Service has encountered individuals perambulating upon an inch of snow on 22nd November and in mild weather on 3rd January.[2] But, on the other hand, Dr Laver informs me that he is sure that in Essex some individuals sleep right through the winter, and a Manx captive in the possession of Mr P. M. C. Kermode slept from Christmas Eve to 19th April following. It is evident that the relative hiemal activity of the animal should be studied from north to south of the country.

After a period of gestation[3] which has been variously computed at from about four[4] to seven weeks,[5] the female produces her young at a date which may be in or about April, or between mid-August and the beginning of October.[6] The number is generally four or five, but varies in exceptional instances between two[7] and eight[8] or nine[9]; litters of seven have been recorded by Mr Harting (twice)[10] and Mr F. H. Parrott.[11] The later births are the second litters of the season, and are always separated from those of spring by the interval mentioned above. The newly born young are blind, and the future spines are hardly perceptible; at first these are white, soft, and flexible, but, hardening in the course of a few days, they become first brown, later annulated. The ears, as remarked by Gilbert White,[12] at first hang downwards, and the sucklings lack the power of rolling themselves into a ball. But they leave the nest in about a month, and grow so rapidly that those of the spring litters are to all appearances fully grown the same season; those of the autumn remain with their mother until they nearly equal her in size, and they, perhaps, share with her their winter retreat.[1] In an interesting article[2] Major Spicer has described the manner of suckling. The mother "lay at full length on her side, or rather nearly on her back, for their convenience, just like an old sow with pigs in a sty, and the young ones worked away at her paps, smacking their lips, and making almost as much noise about it as young pigs would do: their cry when not suckling is a sort of continuous short whistle or chirp, like the cry of a bullfinch, and more like a small bird than an animal."[3] The same mother when confined in a garden with her young ones, which were about the size of small oranges, scratched a hole under the fence and removed them one by one. She carried them by the back of their necks in her mouth, and was strong enough to trot with her burdens raised quite off the ground.

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[1] C. A. Witchell, *Journ. cit.*, 1896, 98; Gordon Dalgliesh, *Field*, 19th November 1904, 908; and *Zoologist*, 1906, 170.

[2] *Ann. Scott. Nat. Hist.*, 1901, 79.

[3] The pairing of this animal, either "standing upright because of their spines" (Aristotle, *De Generatione Animalium*, Arthur Platt's ed., 1910, i., 5, 717^b, 30), "belly to belly" (Aristotle, *Historia Animalium*, D'A. W. Thompson's ed., 1910, v., 2, 540^a, 3), or ventral as in porcupines (Sir Thomas Browne, 311), engaged the curious attention of many ancient and mediæval writers. It has recently been described by R. Collett, who states that the male may follow the female for several hours, after which the pair wander round each other in a small circle till at last the pairing takes place, the female lying on her back. The latter fact was also given by Lilljeborg.

[4] Flower and Lydekker; E. L. Trouessart, *Histoire naturelle de la France*, 1884, 75.

[5] This figure is probably correct, since it was given by Lilljeborg, a very careful writer.

[6] 23rd September for Ireland, *fide* Patterson, *Irish Naturalist*, 1901, 254; 28th September (recently born), Girvan, Ayrshire, Scotland, James Lumsden, *Proc. Nat. Hist. Soc.* (Glasgow), iii., 187, 27th March 1877; H. E. Forrest observed half-grown young near Shrewsbury in the last week of November 1910 (*in lit.*).

[7] Bell; also Cocks.

[8] Blasius.

[9] Collett.

[10] *Vermin of the Farm*, 1892, reprint, 34.

[11] *Zoologist*, 1887, 424.

[12] Letter xxvii. to Thomas Pennant, 22nd February 1770.

Few people seem to have heard a hedgehog utter sounds more distinctive than grunts, snorts, snores, or chuckles[4] of satisfaction. Yet the animal makes a loud noise when in fear or distress, a kind of wail, recalling the cry of a hare when in trouble.[5]

This is probably the same as the shrill cry mentioned by Blundevill in the sixteenth century,[6] and it is variously described as a "whining sound,"[7] or as a long succession of screeches or screams.[8] It was mentioned by Shakespeare in the famous lines[9]—

> "Thrice the brinded cat hath mew'd.
> Thrice; and once the hedgepig whin'd,"

and it probably corresponds to the loud, cat-like squeals of the Eared Hedgehog[10] described by Miss Bate.

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[1] Adams in MS., but hibernation is normally solitary.

[2] *Zoologist*, 1858, 6055-6056.

[3] Edward Jesse, ed. *Selborne*, 1854, 109, wrote of the young that "the incessant cry they make for their mother when hungry leads to their discovery."

[4] Sir R. Payne-Gallwey, *Field*, 26th November 1898, 858.

[5] See above, p. 61, when seized by a badger; also Jones, *Woodcraft*, 1910, 15.

[6] See above, p. 68.

[7] Editor of *Field*, 26th August 1899, 294.

[8] *E.g.*, by Moffat (*in lit.*).

[9] *Macbeth*, Act iv., sc. 1, line 2.

[10] *Hemiechinus auritus* (Gmelin).

In some parts of England[1] country boys have a way of making the poor brutes scream or wail by drawing a small piece of stick to and fro across one of the hamstrings. Mr Jones, who describes this proceeding,[2] thinks that it "really tickles the hedgehog, and makes him laugh in his own peculiar way."

Another cry, habitually uttered by animals wandering about at night, has been likened by Major Spicer to the voice of a calf, and is probably the same note which an anonymous writer described as a kind of "quack, quack, quack."[3] It was compared by Witchell[4] rather to a grunt than a quack, and by other writers to a "quack" or "crake," closely resembling the sound made if the thumb nail be drawn slowly along the larger teeth of an ordinary comb.

Hedgehogs are easily rendered familiar, and will soon partake without fear of the food of other domestic pets, eating at the same time with them and from the same dish. They do not, however, seem to be long-lived.[5] They will allow their faces to be rubbed or keep their bristles smooth to be stroked. They have been harnessed to a small toy cart,[6] and have learnt the meaning of a dinner whistle, running or gambolling up to the call, but retiring with a different air when satisfied. William Thompson of Belfast[7] mentions the fact that they will drink beer to intoxication, and Mr Cocks once tamed a newly caught individual by drenching it with beer as it lay rolled up, and stroking it whenever it uncurled. On recovering sobriety, it remained for the rest of its life perfectly tame.

Hedgehogs must have been tamed from time immemorial, since Aristotle[8] incidentally mentions that those that are kept in domestication shift from one wall to the other, according to the direction of the wind.

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[1] As in Essex, *fide* Laver (*in lit.*).

[2] *Op. cit.*

[3] *Field*, 26th August 1899, 294.

[4] *Field*, 2nd September 1899, 400.

[5] Captain W. Buckley, however, informed Forrest that he believes they reach an age of at least twenty years.

[6] M. J. Simpson, *Irish Naturalist*, 1895, 136.

[7] Quoting from R. Ball, in *The Irish Penny Journal*, 1840-41.

[8] *Historia Animalium*, *ed. cit.*, ix., 6, 612^b.

SORICIDÆ.

SHREWS.

Sub-Family *Soricinæ.*

RED-TOOTHED SHREWS.

Shrews in outward appearance bear a strong resemblance to mice, but their projecting, proboscis-like snout, minute eyes, and comparatively small front teeth or incisors, are distinctive. The following **key** will be found helpful :—

I. EXTERNAL CHARACTERS :—

1. Colour above not darker than "clove brown"; feet and tail not fringed or keeled; hind foot not exceeding 14 mm.	*SOREX* . .	p. 77
(1) Size larger, hind foot 12 to (rarely) 14 mm.; length of head and body to that of tail, nearly as 7 to 3.5 (2 to 1) .	*S. araneus castaneus*	p. 82
(2) Size smaller, hind foot 10 to 11 mm.; head and body to tail, about as 6 to 4 (3 to 2)	*S. minutus* . .	p. 109
2. Colour above blackish slate or slate black; feet fringed and tail keeled with strong (usually white) hairs; hind foot averaging 17 mm. .	*NEOMYS fodiens bicolor*	p. 124

II. SKULLS AND TEETH :—

1. Teeth 32; large upper incisors about equally bicuspid; lower with three basal knobs .	*SOREX* . .	p. 77
(1) Skull larger, greatest length about 19 mm.; posterior lobe of anterior upper incisor with basal length about equal to that of the anterior lobe .	*S. araneus castaneus*	p. 82
(2) Skull smaller, greatest length about 16 mm.; posterior lobe of anterior upper incisor with basal length about half that of the anterior lobe . .	*S. minutus* .	p. 109
2. Teeth 30; large upper incisors unequally bicuspid; lower with one basal knob . .	*NEOMYS fodiens bicolor*	p. 124

GENUS SOREX.

1758. SOREX, Carolus Linnæus, *Systema Naturæ*, x., 53; xii., 73, 1766; based on *S. araneus*—type; see Thomas, *Proc. Zool. Soc.* (London), 1911, 143, published March 1911—and two other species; not *Sorex* of Duvernoy, 1835 = CROCIDURA.

1829. OXYRHIN, Jakob Kaup, *System der Europäischen Thierwelt*, i., 120; based on the indeterminable *Sorex constrictus* of Hermann in Zimmermann, *Geographische Geschichte des Menschen*, etc., 1780, sp. 313; and *Sorex tetragonurus* of Hermann in Zimmermann = *S. araneus tetragonurus*; both described from Strassburg, Germany.

1835. HYDROSOREX (part), G. L. Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), 17th June and 2nd December 1834, 17 and 33, pl. i., figs. 2 and 2*b*, pl. ii., figs. 4 and 5; based on *Sorex fodiens*, description + *S. araneus*, figure of skull of; and *S. tetragonurus* = *S. araneus tetragonurus*.

1838. AMPHISOREX, G. L. Duvernoy, *L'Institut* (Paris), Ann. vi., No. 226, 112, April, and *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), Suppl., 4, 30th January 1838; based on *S. tetragonurus* of Hermann, and other species; preoccupied by *Amphisorex* of Duvernoy, *Mém. cit.*, 17th June and 2nd December 1834 (published 1835), 23, pl. i., fig. 1*b*, pl. ii., fig. 6 = NEOMYS of Kaup, 1829.

1838. CORSIRA, J. E. Gray, *Proc. Zool. Soc.* (London), 1837, 123, published 14th June 1838; based on *S. vulgaris* of Linnæus = *S. araneus*.

1842. OTISOREX, J. E. de Kay, *Zoology of New York*, i., *Mammals*, 22-23, pl. v., fig. 1; based on *O. platyrhinus* of de Kay = *S. personatus* of Geoffroy and *O. longirostris* of de Kay = *S. longirostris* of Bachman.

1890. HOMALURUS, E. Schultz, *Schriften des Naturwissenschaftlichen Vereins des Harzes* (Wernigerode), v., 28; based on *S. alpinus* of Schinz; ?preoccupied by HOMALURA of Meigen, 1826, a genus of Diptera.

Synonymy:—There is in this case fortunately no difference of opinion as to the nomenclature.

The genus *Sorex*, as at present restricted, includes a number of mouse-like forms, all characterised by small size and elongated bodies, and inhabitants of the northern regions of the Old and New Worlds. They are thickly coated with hair, which is changed by a **moult** in spring and autumn. The long and pointed muzzle, which projects considerably in front of the lower jaw, carries the prominent nostrils at its extremity.

The eye is minute, and the sight is probably poor. The ear, although without prominent external parts, is well developed, and the opening is provided with three valves (Plate VI., Figs. 1 and 2), a small one in the position of the tragus, a larger antitragial, and, above the latter, a third, of size similar to the last, situated somewhat in the position of the human antihelix; the two latter carry tufts of hair. Both hand and foot are simple, formed for running, and each has five well-developed, clawed digits, of which the central is the longest. The tail is long and moderately hairy (Plate VII., Figs. 1 and 2). The generative organs, which are much enlarged during the breeding season, open separately from the anus; the vagina is imperforate in the young female; the penis is cylindrical or tapering.

There is no cæcum; the stomach is elongated pylorically, and is not globular as in *Neomys*, to be described below (see Jenyns, *Ann. and Mag. Nat. Hist.*, June 1841, 267).

The **mammæ**, placed inguinally, are normally arranged as three pairs.

There is on each side of the body, at a point situated at about one-third of the distance from the elbow to the knee, a lateral gland (see Linde, Gegenbaur's *Morphologische's Jahrbuch*, xxxvi., 465, 1907), covered by two rows of coarse hairs. From this exudes a secretion to which shrews owe their peculiarly **unpleasant odour**; the gland is especially prominent during the breeding season, at which time also there is an enormous development of the generative organs.

In the **skeleton** there is no pubic symphysis, and the tibia and fibula are united.

The long and narrow **skull** tapers markedly to the snout, and is without zygomatic arch, post-orbital process, or tympanic bulla, the tympanum being ring-like.

Hinton points out that the mandibular condyle affords good generic characters, which are very useful in determining jaws of fossil shrews or those from owls' pellets. Shrews are peculiar among mammals in having two articular facets upon the condyle (Fig. 23, Nos. 1 and 3), an upper (*s*) and a lower one (*i*), widely separated from each other by a non-articular tract of bone. In *Neomys* the lower facet (Fig. 23, Nos. 2 and 4), *i*, is greatly prolonged towards the inner or lingual side, and the non-articular part of the condyle, as seen from behind, is much constricted. In *Sorex* the lower facet is without the lingual prolongation, and the non-articular part is not constricted.

The **dental formula** is probably—

$$i\,\frac{4-4}{2-2},\quad c\,\frac{1-1}{0-0},\quad pm\,\frac{2-2}{1-1},\quad m\,\frac{3-3}{3-3} = 32.$$

The **dentition** (Fig. 24, Nos. 1 and 2, p. 90) is highly characteristic, but the homologies of the five small teeth lying between the large central upper incisors and the last premolar are somewhat obscure, since the premaxillo-maxillary suture disappears very early in life. If Brandt be correct in his assertion (see *Bull. Soc. Imp. des Nats. de Moscou*, xli., iii., 76-95, 1868; xliii., ii., 1-40, 1871; Dobson, *Proc. Zool. Soc.* (London), 1890, 49-51) that in the type of the genus this suture lies between the fourth and fifth teeth, then the first four must be reckoned as incisors—a number unique amongst the higher mammals. On this notation the fifth tooth is a canine; then follow two premolars, the first minute, the second large, and three molars; but it is simpler to style all between the central incisors and the molariform teeth as unicuspids. The notation of the lower teeth is that of Dobson, and is based on his having found a minute seventh tooth, thought to be a

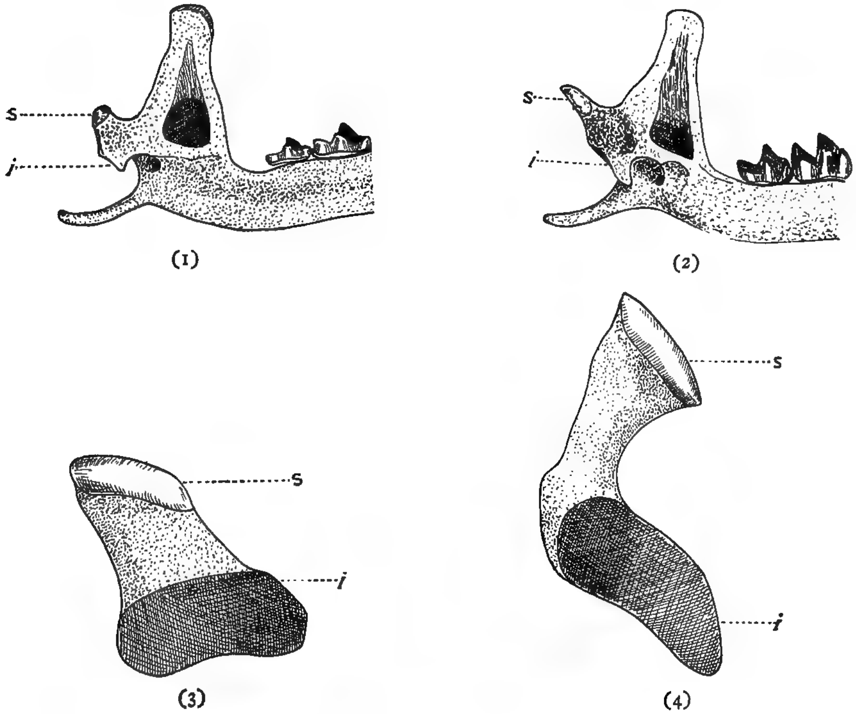

FIG. 23.—MANDIBULAR ARTICULATION OF *Soricinæ*. (Drawn by M. C. A. Hinton.)

Inner view of posterior part of left ramus of (1) *Sorex araneus*, and (2) *Neomys fodiens*. In (3) and (4) the respective condyles are shown in posterior view, much enlarged, *s* and *i* being the superior and inferior articulating surfaces.

canine, lying between the second and third of the series in *Myosurus varius* (*Journal of Anatomy and Physiology*, 1886, 359).

The conspicuous front tooth of the upper jaw (central incisor) is stout and hook-like, and is provided posteriorly with a large basal cusp or knob; then follow the five unicuspids formed as compressed triangles. The upper molars have cusps exhibiting a **W**-shaped pattern. In the lower jaw the first incisor projects horizontally forwards, and has on its upper surface three distinct lobes behind the prominent cutting edge; the smallest tooth in the set follows next to it, the premolar being slightly larger.

The summits of the teeth are coloured reddish-brown.

The teeth are well developed and the cranial sutures anchylosed—in most mammals a true test of maturity—very early in life. The last to close is the basi-occipital suture, which is accordingly the best guide to the age of a specimen.

Shrews make their first appearance in the Oligocene of North America and Europe (Osborn). The genus *Sorex*, although, if correctly identified, it is coeval with the sub-family in Europe, is unknown in North America before the Pleistocene (Osborn), and in Britain before the late Pliocene.

As the result of a recent examination of **British fossil shrews,** Hinton has found two extinct species in the late pliocene Forest-Bed. One of these, which he names *S. savinii*, is distinguished as the largest British species hitherto discovered; the other, which he calls *S. runtonensis*, is a form not much larger than *S. minutus*. A third extinct species is known to occur in the pleistocene (Middle Terrace), brickearth of Gray's, Essex, and was almost of the same size as *S. araneus;* and still another form, which Hinton names *S. kennardi*, has been found recently in a later pleistocene (Third Terrace) deposit at Ponder's End, Middlesex. The latter was intermediate in size between *S. araneus* and *S. minutus*, and its skull and jaws present some features which suggest affinity both with the latter species and with *S. alpinus*. Hinton's complete descriptions will appear in the *Geological Magazine*.

The **most nearly allied genera** are *Soriculus* of the Oriental region, without separate orifices for anus and generative organs;

the American *Notiosorex*, with only twenty-eight teeth; the short-tailed *Blarina*, also American; and the familiar *Neomys*, or water shrews. These constitute the sub-family *Soricinæ*, or red-toothed shrews, which are thus readily distinguished from the *Crocidurinæ*, or white-toothed shrews, a sub-family with two European genera, *Pachyura* and *Crocidura*. The latter is numerous in species, and represented on the continental shores of the English Channel and even in the Channel Islands (Sinel). It was a *Crocidura* that was mummified by the ancient Egyptians.

The two **British species** of *Sorex* resemble each other so closely that they are often confounded. They are extremely active, quarrelsome, and voracious animals, very widely distributed all over the country, and the larger of them at least in great abundance. They spend their time in an almost incessant pursuit of such living things, chiefly invertebrates, but occasionally vertebrates—even their own species—as they can overpower; and their unreasoning and undiscriminating ferocity is indicative of low brain power. They may consume vegetable matter in times of scarcity, but there is little evidence of this for wild individuals in Britain. The breeding season lasts for nine months of the year, and they produce as many as eight or ten young at a time. These, which are naked and helpless at birth, are deposited in a warm nest, where they grow rapidly. Although, owing to their enormous appetite, shrews soon become reconciled to captivity, they usually die after a few weeks; indeed, so many dead carcases are found lying about in open places, especially towards the end of summer, that it seems probable that the span of their natural existence is brief, perhaps not exceeding a year or thereabouts.

They swim well and can climb when occasion arises, but probably dig little, preferring to occupy natural crevices or the runs of small rodents. They do not hibernate.

Shrews are of delicate constitution, and readily succumb to injuries.

They possess an unpleasant **odour**, so that many carnivorous animals will not readily eat them, and, owing to the character of the contents of their intestines, when killed they undergo a rapid putrefaction.

A third European species, *S. alpinus* of Schinz, inhabits the Pyrenees, Alps, Harz Mountains, Riesengebirge, and Carpathians; it is a dark, slate-coloured shrew, about the size of *S. araneus*, but with a long tail of about the same length as the head and body, and distinctive skull and teeth.

THE COMMON SHREW.

SOREX ARANEUS, **Linnæus.**
SOREX ARANEUS CASTANEUS **(Jenyns).**

1667. MUS ARANEUS, *the Erdshrew* or *Field Mouse*, Christopher Merrett, *Pinax*, 167

1758. SOREX ARANEUS, Carolus Linnæus, *Systema Naturæ*, x., 53; xii., 74, 1766; described from Upsala, Sweden; Bingley; Donovan; Fleming; Jenyns; Bell (ed. 1); MacGillivray; Thomas, *Zoologist*, 1895, 63; Millais; Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, May 1905, 506; Trouessart (1910); Collett; not *S. araneus* of Schreber and others = Hermann's *Sorex* (now *Crocidura*) *russula.*

1764. SOREX VULGARIS, Carolus Linnæus, *Museum Regis Adolphi*, &c., 10; renaming *S. araneus;* Nathusius, Wiegmann's *Archiv. für Naturgeschichte*, 1838, i., 45; Owen; Blasius; Fatio; Bell (ed. 2); Woodward and Sherborn; Flower and Lydekker; Lydekker; Johnston; Winge.

1780. SOREX TETRAGONURUS, Johannes Hermann in E. A. W. Zimmermann's *Geographische Geschichte des Menschen*, &c., ii., sp. 312, 383; described from Strassburg, S. Germany; Schreber, *Die Säugthiere*, Supplement, iii., pl. clix*b*, 1781; Hermann, *Tabula Affinitatum Animalium*, &c., 1783, 79, footnote; MacGillivray (appendix); Clermont; Alston, *Fauna of Scotland*, 1880, 9.

1792. SOREX QUADRICAUDATUS, Robert Kerr, *Animal Kingdom*, 208; renaming *S. tetragonurus* of Hermann.

1800. SOREX ARANEUS ALBUS, J. M. Bechstein, Thomas Pennant's *Algemeine Uebersicht der vierfüssigen Thiere*, ii., 722; described from a white variety.

1801. SOREX CUNICULARIUS, J. M. Bechstein, *Gemeinnutzige Naturgeschichte Deutschlands*, ed. 2, i., 879; described from Thuringia, Germany.

1828. SOREX CORONATUS, P. A. Millet, *Faune de Maine et Loire*, i., 18; described from Blou, Maine et Loire, France.

1828. SOREX PERSONATUS, P. A. Millet, *Op. cit.*, i., 18, footnote; a rejected MS. name for *S. coronatus*; not *S. personatus* of I. Geoffroy, 1827.

1832. SOREX CONCINNUS, J. Wagler, Oken's *Isis* (Jena), 54 and 275; described from Bavaria.

1832. SOREX RHINOLOPHUS, J. Wagler, *Journ. cit.*, 54; described from Bavaria.

1832. SOREX MELANODON, J. Wagler, *Journ. cit.*, 54; described from Bavaria.

1835. HYDROSOREX TETRAGONURUS, G. L. Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), 17th June and 2nd December 1834, 19 and 33, pl. i., figs. 2 and 2*b*, pl. ii., fig. v.

1838. CORSIRA VULGARIS, J. E. Gray, *Proc. Zool. Soc.* (London), 1837, 124, published 14th June 1838.

1838. SOREX TETRAGONURUS, var. *β*, S. CASTANEUS, Leonard Jenyns, *Ann. Nat. Hist.*, i., 424, August; ii., 43, 1839; vii., 266-267, 1841; see also *Mag. Zool. and Bot.*, ii., 39, 1838; described from Burwell Fen, Cambridgeshire, England.

1838. AMPHISOREX TETRAGONURUS, G. L. Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), Suppl., 4, 30th January; and *L'Institut* (Paris), *Ann.*, vi., No. 226, 112, April.

1839. SOREX LABIOSUS, Leonard Jenyns, *Ann. Nat. Hist.*, ii., 326, January; described from Frankfort-on-Maine, Germany.

1839. SOREX MACROTRICHUS, E. de Selys-Longchamps, *Études de Micrommalogie*, 20; from Mehliss' MSS.; ? adult in winter.

1846. SOREX FODIENS and SOREX REMIFER, Sir Richard Owen, *British Fossil Mammals*, &c., 28, in error.

1855. AMPHISOREX VULGARIS, C. G. Giebel, *Säugthiere*, 900.

1868. SOREX VULGARIS, PALLIDUS, L. J. Fitzinger, *Sitzungsberichte der Kaiserlichen Akad. der Wissenschaften* (Vienna), lvii. (1), 488; naming a pale variety without locality from Bonaparte, *Fauna Italica*, pl. xviii.

1869. SOREX VULGARIS, VARIETAS NUDA and VARIETAS NIGRA, Victor Fatio, *Vertébrés de la Suisse*, i., 127; described from the Bernese Oberland and from Lucerne, Switzerland, and based on worn and winter specimens respectively of *S. a. tetragonurus;* see Mottaz, *Bull. Soc. Zool.* (Geneva), i., 9, 15th November 1908, 153-154.

1870. SOREX INTERMEDIUS (part), E. Cornalia, *Catalogo descrittivo dei Mammiferi osservati fino ad ora in Italia*, 27 (not seen); described from hills of Brianza, Italy; although quoted under *S. alpinus* by authors, is based upon a made-up specimen of *Sorex* and *Neomys*; see Sordelli, *Atti della Soc. Ital. di Sci. Nat.*, xxxviii., 362-365, 17th December 1899.

1885. CROSSOPUS REMIFER, R. Lydekker, *Catalogue of Fossil Mammalia*, i., 17, in error.

1890. HOMALURUS VULGARIS, E. Schultz, *Schriften der Naturwissenschaftlichen Vereins des Harzes* (Wernigerode), v., 28.

1900. SOREX VULGARIS, "var. vel. subsp. MOLLIS," Victor Fatio, *Rev. Suisse de Zool.*, 8, 471; renaming his var. *nigra* of 1869; see Mottaz, *Bull. Soc. Zool.* (Geneva), i., 9, 15th November 1908, 154.

1901. SOREX ARANEUS ALTICOLA, G. S. Miller, junior, *Proc. Biol. Soc.* (Washington), xiv., 43, 25th April; described from Meiringen, Switzerland = *S. araneus nuda* and *S. a. nigra* of Fatio; see Mottaz, *Mém. de la Soc. Zool. de France*, xx., 24, 26, 1907.

1905. SOREX VULGARIS CRASSICAUDATUS, Victor Fatio, *Archives des Sci. Phys. et nat.* (Geneva), xix., 201, 15th February; described from Zermatt, Switzerland = *S. araneus alticola* of Miller; see Mottaz, *Mém. de la Soc. Zool. de France*, xx., 24, 1907, and *Bull. Soc. Zool.* (Geneva), i., 9, 15th November 1908, 166.

1905. CROSSOPUS ou SOREX IGNOTUS, *Auct.* and *Journ. cit.*, 201-202; described from Switzerland and based on *Neomys fodiens* (skull) + *Sorex* (jaw); see Mottaz, *Bull. Soc. Zool.* (Geneva), i., 9, 15th November 1908, 167.

La Musaraigne vulgaire of the French: *die Waldspitzmaus* of the Germans.

As the **synonomy** of the species *S. araneus* has not been recently published in detail, it seems useful to print it as above, and not to be content with the names which have been applied only to the British sub-species. There are omitted, therefore, only certain recent sub-specific names, which have neither been applied to the British Common Shrew nor affect the treatment of the species as a whole. These will be found under heading of Geographical Variation. *Castaneus* was undoubtedly the first name bestowed definitely by its describer on a British Common Shrew, and is therefore applicable to the native subspecies.

The majority of the technical names are based upon differences due either to age, season, or individual variation. At least two, viz., *tetragonurus* and *castaneus*, have reference to sub-specific differences; not, however, those observed by the original describers. Two, *fodiens* and *remifer*, have been transferred in error from another species. Although *araneus* has undoubted precedence by priority for the species as a whole, there has been in the past much confusion and misuse in its application, as well as in that of *vulgaris* and *tetragonurus*. This arose from the fact that, whereas in Skandinavia, as in England, there are but two species of shrews, both red-toothed or true *Sorices*, on the Continent of Europe generally there occur also the white-toothed shrews of the genus *Crocidura*. To one of these, *C. russula* (Hermann), being the commonest species of middle Europe, the name *araneus* was at first somewhat naturally applied. When the identity of Linnæus's *araneus* was discovered, some naturalists substituted for it the name *vulgaris*, which, however, is antedated by *araneus*. Others, amongst them MacGillivray and Alston, used the next available synonym, *tetragonurus*, but none of them ventured to alter the name of the *Crocidura*. This is, however, a case where, as Thomas has shown, the rules of priority admit of no doubt, and accordingly they are followed here.

Jenyns in his *Manual* was the first to doubt the identity of the animals styled by British and continental writers *araneus*, a suspicion which developed into conviction after he had read Duvernoy's paper of 1838. In that year Jenyns published an excellent essay, wherein, besides minutely describing the dentition of the British Common Shrew, he suggested the identity of British and Linnean *araneus* with Hermann's *tetragonurus* (see *Mag. Zool. and Bot.*, 1838, ii., 24-42; *Ann. Nat. Hist.*, August 1838, 422-427; September 1838, 43; and 1841, 263-268).

Terminology:—In the works of some writers shrews are known as shrew-mice, but the Anglo-Saxon forerunner of the word was used only as a substantive. Later, in consequence of the mischievous character attributed to the animal, the word "shrew" became an adjective, having the meaning "biting" or "noxious." Since the term "shrew-mouse" suggests a relationship which does not exist, its retention seems to be undesirable.

The older form *schrewe* came from the Anglo-Saxon *scrēawa*= a shrew-mouse, as explained in Wright's *Anglo-Saxon and Old English Vocabularies*, Wülcker's (2nd) ed., 1884, col. 122, line 20:—"Mus araneus, *scrēawa*." To the Latin *araneus*, which means "poisonous as a spider," may be traced "ranny," a word used by Sir Thomas Browne and still surviving in country districts, through an old French form *araigne* = a spider, as the old French ending *-gne* corresponds regularly to the English *-nny*. In Somner's *Anglo-Saxon Dictionary* (1659), scrēawa is explained as "a shrew-mouse, which by biting cattle so envenoms them that they die." This was a belief of ancient date (see below, p. 100).

The Old Norse form of shrew is represented by skrew (or screw), and skrow, as in Scotland, Devon, Cornwall, and Ireland (*Dial. Dict.*).

Local names (non-Celtic):—*Blind mouse* of Cumberland and North Lincoln. *Harvest-mouse*, *harvest-shrew*, *harvest-shrow*, with their countless corruptions, producing *arti-shrew*, *harti-shrew*, *hardy-shrew*, *hardi-straw*, *harvest-trow*, *harvest-row*, *hardy-mouse*, and others, are very widely spread (see *Dial. Dict.*). Of these, some are old forms, as shown by the passage "In Italy the hardy shrews are venomous in their biting," found in Holland's translation of Pliny (b. viii., c. 58, 1601). This ancient superstition has helped the form *harvest-trow*, since "trow" or "troll" is a malicious elf or goblin; and the name may easily be transferred to true mice, as when Jefferies wrote:—"The nests of the harvest-trow—a still smaller mouse, seldom seen except in summer" (*Wild Life in a Southern County*, 1879, 186). The extreme corruptions are hardly recognisable, and have received other interpretations; thus, *ard-shrew*, through *erd-shrew*, has been connected with *earth-shrew*, while *nossro* (n-ossro, *Dial. Dict.*) has been translated as *nose-shrew*, and has many variants, as *nurserow* and *nostril*. *Over-runner* of Wiltshire (Harting, *Vermin of the Farm*, 22). *Pig-mouse* of Surrey (Dalgliesh, *Zoologist*, 1906, 274) and Northampton (Adams, MS.). *Ranny*, explained above, of Scotland and many parts of England (see *Dial. Dict.*). *Shear-* or *sheer-mouse*, *sheery-* or *sherry-mouse*, *shirrow*, *shrove-mouse* (as in Bellamy), *shrow-crop*, *straw-mouse*, and many others of various localities, of which the first four may mean "biting" or "cutting," but are probably mere corruptions or mutilations of shrew; the last but one explains the term "shrow-croped," applied in Devon to an animal supposed to have been paralysed by a shrew creeping over its back.

(Celtic):—Irish—*luch féir* (=grass-mouse). Scottish Gaelic—*Beathachan* (*Beothachan*)-*feoir* = "grass-beast"; *dallag* (*-feoir*) = "blind one"; *feornachan*; *fionnag-feoir*; *labhallan* (*lamhalan*); *luch fheoir*; *luch shith*; *truth*. Manx—*thollag-airhey* (Kelly). Welsh—*chwistl*; *llygoden goch* (=red mouse); *llygoden y maes* (=field-mouse).

The local names, including the Celtic, must be taken without reference to any particular species, except where, as in Ireland and the Isle of Man, the Pygmy Shrew alone occurs. The names peculiar to the Water Shrew will, however, be given under that species.

Distribution:—Shrews of the present type are found throughout arctic, boreal, and transitional Europe and Asia, from sea-level to at least 6000 feet (Blasius); and from Great Britain to the Sea of Okhotsk (where the representative is *S. buxtoni* of Allen, described from Gichiga), as well as in Sakhalin and Hokkaido (representative, *S. diphæonodon* of Thomas). In Norway they are, perhaps, the commonest of all mammals right up to the snow-line on the mountains (Collett), and range from the extreme north (71° 10′ N. lat.), together with corresponding latitudes in arctic Russia, southwards to beyond the Pyrenees, middle Italy, Hungary, ?Turkey, ?Greece, and northern Caucasus; but exact details are wanting for Asia, and even for southern Europe, where *Sorex* tends to be replaced by *Crocidura*, as is the case in the Mediterranean islands, in Asia Minor, and in northern Africa. *S. araneus* has only recently been proved to occur in Spain, although often wrongly reported and evidently confounded with Cabrera's *Neomys anomalus*. It is represented in Alaska by *S. pribilofensis* of Merriam, of the Pribiloff Islands, Bering's Sea; and in North America by the closely related *S. richardsoni* of inexactly known distribution in boreal zones from Ontario and Wisconsin, westwards to Alberta, and north to Great Bear Lake (Thompson Seton). That it crosses the arctic circle in Siberia is proved by Dobson's specimens from the Khatanga and Olenek rivers mentioned in *Proc. Zool. Soc.* (London), 1891, 350.

The Common Shrew is numerous throughout the mainland of **Great Britain** to the extreme north of Scotland (Kinnear, *Ann. Scott. Nat. Hist.*, 1907, 49), as well as in Anglesey, Bardsey, whence Coward has sent me specimens, Wight, and Jersey (Bunting). It frequents every kind of locality from sea-level probably to the summits of the mountains, *e.g.*, to 1300 feet in Yorkshire (Clarke and Roebuck), and at least 1500 feet in Cheshire (Coward and Oldham). It is absent from **Ireland**, Man, Lundy, the Outer Hebrides and Orkneys, where *S. minutus* is alone found; but, despite statements to the contrary, it is present and often common on many of the Inner Hebrides, such as Islay (W. Evans, *Ann. Scott. Nat. Hist.*, 1905, 116; Russell, *Zoologist*, 1910, 113) and Jura, from which last I have examined specimens procured respectively by W. Evans and the late Henry Evans. It is common in Arran and Mull (Alston), occurs in Skye (Buxton, *Zoologist*, 1908, 189) and Bute (Boyd Watt), and doubtless frequents many of the smaller islands. It is doubtful if any shrew is found on the Shetlands, and the species said to occur on Iona (see Lydekker, also Harvie-Brown and Buckley) has not been identified.

Distribution in time:—*Sorex araneus* first appears in Britain in the latest Pleistocene deposits, *e.g.*, those of the Ightham Fissures, Kent, and the Dog Holes Cave, Warton Crag, Lancashire. It has been recorded from several older horizons, but Hinton's recent study of the material upon which these records were based has shown that in all cases the specimens are referable to other and extinct forms (see above, under genus *Sorex*, p. 80).

Description (taken from 250 British specimens):—In form the Common Shrew is typical of its genus (see above, p. 77, etc.). The body is shortened and the back elevated when at rest, but capable of considerable extension when the animal runs. The rounded pinna of the ear is small, and scarcely visible above the fur. The whiskers or vibrissæ are well developed and reach a length of 12 mm.

The **hand** and **foot** (Plate VIII.) have the soles naked, but covered with small tubercles, and the under side of the digits transversely corrugated. Except that the hand is much shorter than the foot, the general plan of each is similar. The central digit is slightly longer than the fourth, and the fourth than the second. These three digits arise from about the same position; the first and fifth are much shorter, especially the first, and arise well behind the other three. The tip of the first (both in hand and foot) reaches only to about the pad at the base of the second; the fifth reaches just beyond the base of the fourth (compare Lesser Shrew below, p. 112). There are six prominent pads, placed one each at the bases of digits one, two and five, one at the junction of digits three and four, and two posteriorly on the sole, one each behind the pads of digits one and five.

The **tail** varies in length, but is generally about half as long as the head and body; it is often four-sided, the angles being rounded, not sharp; it is of nearly equal diameter throughout its length, not tapering to the extremity; it is covered throughout its length with a number of short, closely set, and rather stiff hairs, but is without the inferior "keel" of *Neomys fodiens* (see Plate IX., Fig. 2, and Plate X., Fig. 2, for head; for tail, Plate VII., Fig. 2; for hand and foot, Plate VIII., Figs. 1 and 2; for ear, Plate VI., Fig. 1).

The **fur** is thick, soft, and silky, reaching on the back in winter a length of about 5 mm., but being about 2 mm. shorter in summer.

The **colour** of the upper side from the back of the head or occiput to the base of the tail is in winter usually very deep "seal brown," almost "clove brown," passing rather suddenly on the flanks into a band, about 7 mm. broad, of "broccoli brown," or "wood brown," and thence insensibly without line of demarcation into the dirty or yellowish white of the underside and feet. The dorsal area of brown is broadest over the lumbar region and narrowest just behind the shoulders. The face, and sometimes the head, is lighter than the back. The line of demarcation is indistinct, and runs from a point anterior to the angle of the mouth on each side to the shoulder, whence it coincides with the upper border of the above-described "flank-band,"

and terminates near the anus. The tail is bicoloured—"seal brown" above, "broccoli brown" below.

In summer the upper side is typically grizzled "mummy brown," many of the hairs being tipped with lighter shades. The flank-band is less clearly defined, and there is a stronger wash of yellowish on the under surface.

The first coat of the young resembles that of the parents in summer, and also that of the adult Pygmy Shrew, but displays a peculiar iridescence which is lost in adults (English). The hidden basal portions of the hairs are everywhere and at all seasons "clove brown," or "slate black."

A **moult**[1] occurs normally twice a year, viz., in spring (instances examined from 12th April to 14th June) and in autumn (14th September to 7th October). Frequently, but not invariably, the change is seen first on the head in spring, proceeding abruptly backwards and frequently leaving a sharp division between the fore parts of the body, which may be in summer coat, and the hinder parts, which may still carry the winter pelage. The winter coat is resumed in the reverse order, starting from the posterior end of the body, so that in autumn again there are found individuals in which the fore and hinder parts of the body are in different pelages.

The square appearance of the tail, which gave rise to the technical name *tetragonurus*, is most evident in the summer months, when the hairs have been shed or are worn down. In this condition the angles are rounded and not sharp, and the shape of these arises from the vertebræ as seen through the skin. At the same time the feet are often naked and the ears bare. The dates at which these parts (feet, ears, and tail) are found bare suggest that they may not follow the routine of the pelage moults, but may change their hairs only once a year at a variable date during summer.

Common Shrews exhibit a high degree of **individual variation,** the cause of which is not understood. The tints of the upper and under sides are especially liable to aberration from the normal, and the flank band may be entirely absent, its place being taken by a quite indefinite line of demarcation. Much irregularity is manifested in regard to the exact time of the moult, and many specimens are found with the long winter coat combined with the colours of summer, and even more frequently with the short summer coat coloured as in winter. These suggest the coloration of certain continental subspecies. I find considerable uniformity of colour in September, just before the autumnal moult.

Extreme summer specimens reach tints in the neighbourhood of "wood brown," and so merge into true *S. castaneus* of Jenyns, a rufous variety of a "tint, in the recently killed animal, . . . quite as bright and decided as in the harvest-mouse or squirrel."

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[1] These moults and the manner in which the fur is changed were mentioned by Witchell and Strugnell, *Fauna and Flora of Gloucestershire*, 1892, 9.

Specimens from East Anglia are usually more brightly coloured, with darker back, sharper line of demarcation, and more plainly marked "flank-band," which in winter results in a distinctly tricoloured appearance. The summer coat is often almost as dark as that of winter, and melanism generally is frequent, in which case the flank-band may be obliterated. This form appears to approach, if indeed it be not identical with, the subspecies *S. a. araneus* of central Europe.

The length of the tail is a very variable feature.

Exceptional colour-variation and sports:—Melanism is rare in *S. a. castaneus*, but frequent in true *araneus*. Gurney records an example of this kind of variation from Norfolk (*Zoologist*, 1879, 123).

Albinism is much more abundant than melanism in British shrews, and the occurrence of at least four albinos, in one case a male with pink eyes, has been placed on record (Bartlett, *Journ. cit.*, 1843, 287; Grabham, *Journ. cit.*, 1895, 268; Hollis, *Journ. cit.*, 1910, 307; Forrest, MS.). Other less definitely described specimens are an "albino" mentioned by Coward and Oldham, a small white female from Somerset, in the British Museum, and two in J. Whitaker's collection (see *Field*, 19th February 1910, 333). Service has figured a cream-coloured specimen (*Ann. Scott. Nat. Hist.*, 1896, 202; and 1903, 67, pl. i.); another was noticed in 1868 (Bladon, *Zoologist*, 1868, 1096), while a white shrew with brown tail-tip and a slight ashy tint on the upper side both of head and body is in the Royal Scottish Museum (Traquair, *Ann. Scott. Nat. Hist.*, 1902, 117).

Partially white specimens are quite frequent; sometimes they are whitish all over, or they may be finely powdered with white so as to resemble somewhat the colour and appearance of a "roan" horse. But more often the white appears either as a tip to the tail, or as a spot near or over the occiput, between, but a little behind, the ears. This is probably the "grey patch" which English has known to be developed on the head of a captive specimen and which he suggests may be due to poor condition. Of the latter variety I have examined five specimens. Many (in some localities the majority) have conspicuous white hairs on the ears, and others have spectacle-like marks around the eyes. Perhaps the most remarkable recorded variation is the pied skin described by Bell as having a broad white band over the loins, extending completely around the body; the interest of this variety is increased by the fact that Rope has met with an almost similar one (*Zoologist*, 1883, 220).

The general characteristics of the **skull** and **dentition** have been already described under the heading of the genus. In *S. araneus* the skull is rounder, larger, and more strongly built than in *S. minutus*. The teeth (Fig. 24, No. 1), are markedly larger, and the relative size

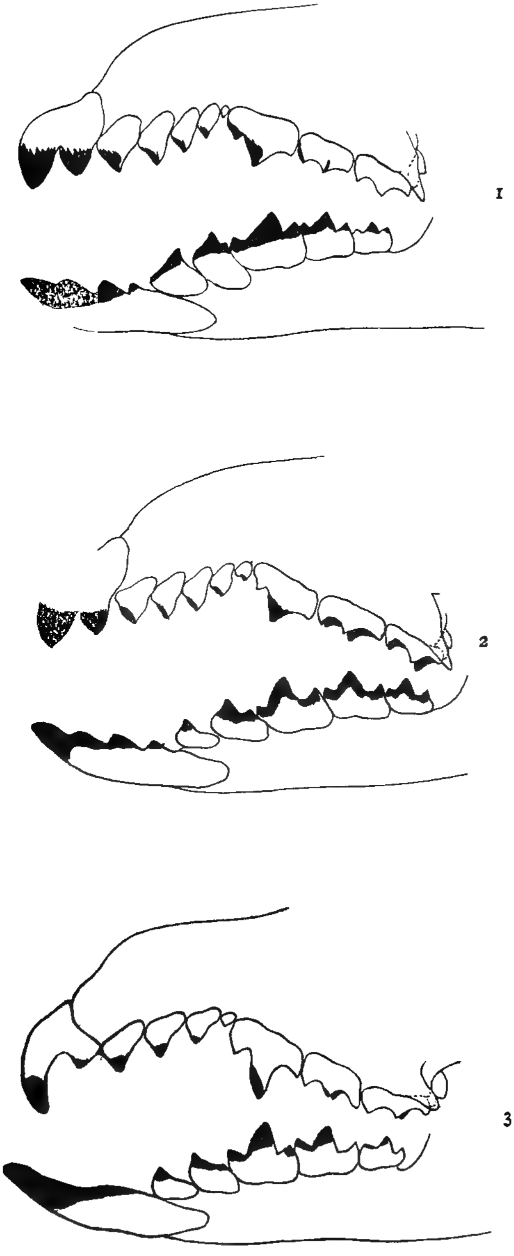
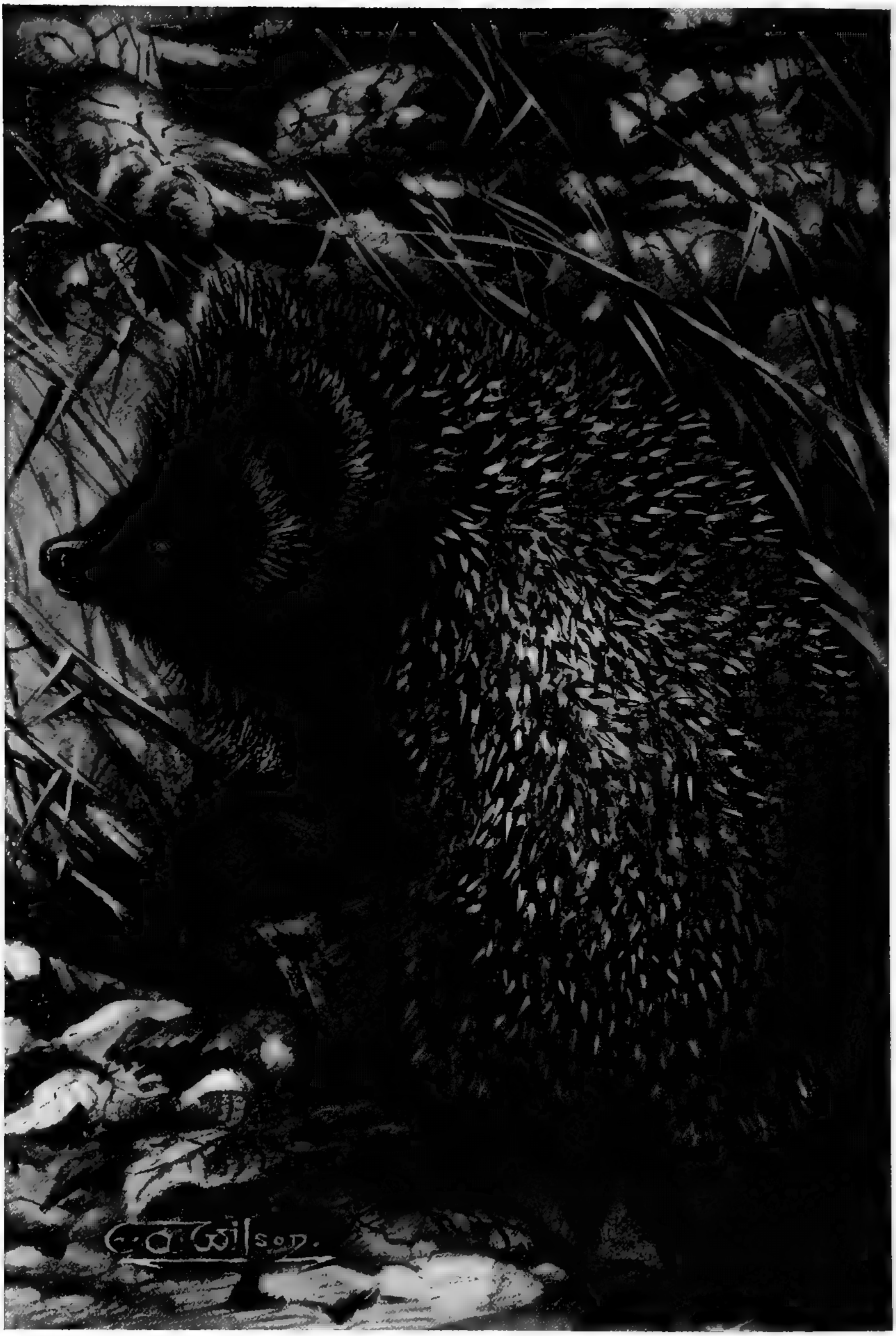


FIG. 24.—SIDE VIEW (diagrammatic and greatly enlarged) OF TEETH OF—(1) *Sorex araneus;* (2) *Sorex minutus;* and (3) *Neomys fodiens.* The portions of the teeth shown black in the diagram are in nature reddish.

PLATE IV.



THE HEDGEHOG.

of the unicuspids of the upper jaw is different. In both species they decrease in size gradually from front to back like a flight of stairs, but, whereas in *minutus* the first three teeth are not of markedly uneven size, in *araneus* the third is very distinctly smaller than the second, so that the "step" between these two teeth is abrupt. In both species the last unicuspid is minute, especially so relatively in *araneus*, in which it often lies so much interior to the general line as to be barely visible from the outside. In the first upper incisor the posterior lobe is relatively thicker than in *S. minutus*, the length of its base being about equal to that of the base of the anterior cusp; and in the first lower incisor the three lobes diminish regularly in basal diameter from front to back, but with the largest gap between the first and second. But it must be remembered that all these distinctions, except the first and last, undergo fundamental alterations as the sharp points of the teeth wear away with age and use.

Geographical variation:—The colours of the British Common Shrew (*S. a. castaneus*) are duller than those of *S. a. araneus*, which is a brighter and more distinctly tricoloured animal, ranging from eastern Skandinavia to central Europe, and, as stated above, probably also to the east of England. Each of the above has the tail as a rule less than, or not exceeding, 45 mm. long. Two other sub-species, *S. a. tetragonurus* (Hermann), of the Alps and neighbouring regions east to Transylvania, and *S. a. pyrenaicus* of Miller, of the Pyrenees, are characterised by a tail usually exceeding 45 mm. in length. The former is a darkly-coloured animal with the back frequently blackish in summer; in the latter the back is never blackish in summer. Miller has further described:—*S. a. euronotus* of the plains of south-western France, a dully coloured animal, with slight cranial peculiarities; *S. a. fretalis* of Jersey, with the rostrum deepened and broadened, and the anterior teeth enlarged; *S. a. granarius*, known only from Segovia, Spain, the smallest known form, with a skull resembling that of *S. a. fretalis;* and *S. a. bergensis*, a large dark shrew from the Atlantic slope of western Norway. *S. a. santonus* (Mottaz), from Charente, France, has blackish under-parts not in contrast with the back. Miller unites my *S. a. carpathicus* from Transylvania with *S. a. tetragonurus* (see Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, May 1905, 505-508).

Another sub-species, *S. a. borealis* of Kashtchenko, described from western Siberia, is not available for examination. No doubt the American *S. richardsoni*, being only distinguishable from *S. araneus* by its longer coat, slightly darker coloration, and some details of dentition, may be regarded as of merely subspecific value.

DIMENSIONS IN MILLIMETRES :—

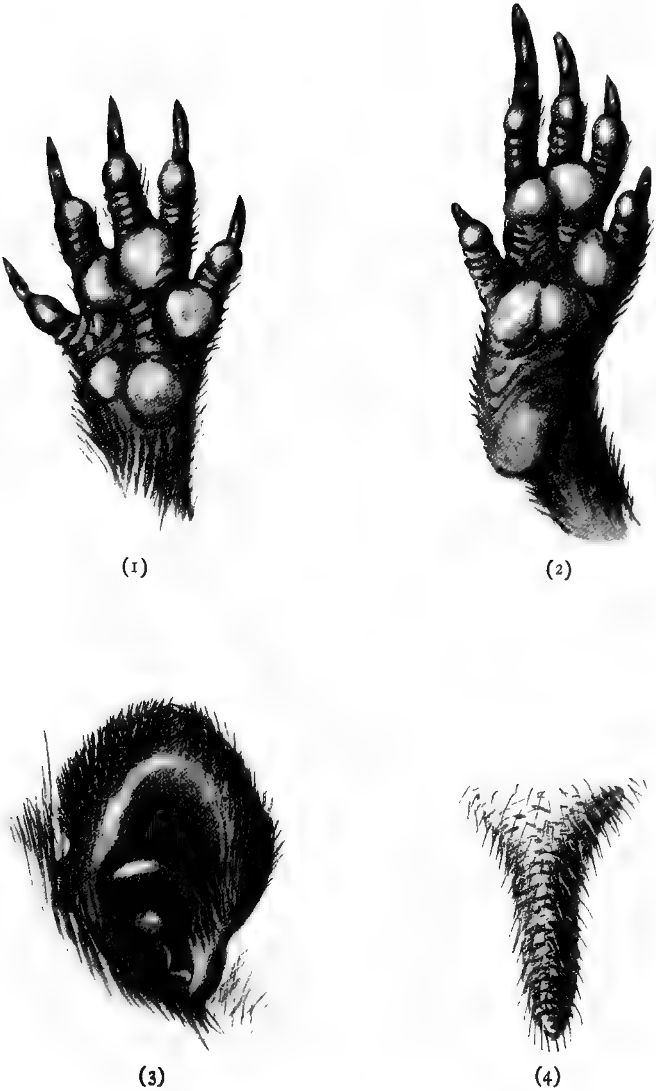
	Head and body.		Tail (without terminal hairs).		Hind foot (without claws).		Ear.		Weight in grammes. (*Fide* Adams.)
	Males.								
No. of items . .	63	219	61	188	61	181	12	40	62
Maximum . . .	82	84	45	47*	14	14	8·5	8	14
Average . . .	74	72·5	39	40	13	12·7	7·45	7·8	10·6
Minimum . . .	62	64	32	35	..	12	6	6	6·5
	Females.								
Number of items .	99	166	99	155	99	145	32	31	65
Maximum . . .	83	84	46	47*	14	14	8·5	8	16
Average . . .	70	72	38·5	39·5	13	12·6	7·7	7·1	9·2
Minimum . .	58	60	33	30	..	12	6·5	6	6

* Twice only for each sex.

Of the **dimensions** given in the above table, those in the left-hand columns were taken from the labels on specimens in the British Museum of Natural History, immature examples being, so far as possible, excluded. Those in the right-hand columns were sent me by Adams, and the two sets agree so closely, as well as do others received from Buckinghamshire (Cocks) and Devonshire (Hollis), that the averages may be taken as fairly correct for specimens all the year round. But, as shown by Adams, to whom I am indebted for numerous valuable notes amplifying his paper (noticed on p. 108), the average size of adults varies throughout the year, being at its maximum in June, and thereafter decreasing until winter, and, if his contention be true that the life of a shrew reaches only about a year, then true adults would only be obtainable from May to December, and during the rest of the year all specimens would be immature. It follows that an average, taken from specimens captured at a particular season would not agree with that for the complete year. Thus, twenty-four adult males taken by Adams in May, June, and July, 1911, averaged 81 for length of head and body, and reached, in two cases, a maximum of 84. Eighteen females taken under the same conditions averaged 82, and reached the same maximum six times. The largest specimen of which I have a reliable record was taken by Kinnear in Scotland; it reached 88 (head and body), 39 (tail), 13 (hind foot).

Allen found that in *S. buxtoni* (*Bull. Amer. Mus. Nat. Hist.*, 1903, 181), an East Siberian representative of *S. araneus*, males are larger

PLATE V.



(1) (2) (3) (4)

The Hedgehog.

(1) Left Hand; (2) Left Foot; (3) Left Ear; and (4) Dorsal View of Tail.
(1, 2, and 3 magnified 1½ times; 4, life size.)

than females, but this is not supported by the figures given above for British shrews, amongst which no recognisable difference in size between the sexes has been shown to exist.

Proportionate lengths:—Tail (without end hairs) about ·5; hind foot about ·17 to ·18; ear about ·1 of head and body.

The **weight** (in grammes) shows a seasonal variation corresponding to the dimensions. Adams's twenty-four males noticed above averaged 12, with a minimum of 10 (once) and a maximum, reached three times, of 14. The discrepancies were generally due to the amount of food contained in the stomach. Adams's eighteen females varied between 9 (once) and 16 (twice), and averaged 13·1, their superiority over the males being due to the fact that many of them contained embryos. An increase of weight after March is independently corroborated by Kinnear (MS.). The facts have an important bearing on the much-discussed autumnal mortality discussed below on pp. 104-108.

Skull:—Greatest length, 19; basal length in middle line, 16; palatal length in middle line, 8; length of upper tooth-series, 8 to 8·5; ditto of lower, 7·5 to 8; greatest breadth, 9; breadth at constriction, 4.

Status, etc.:—The distribution, both modern and geological, of *Sorex araneus* points to its having first appeared in Britain at a comparatively recent date. As compared with *S. minutus*, its greater plasticity and more marked tendency to individual variation indicate a more recent species. In its more complicated changes of pelage it is more specialised, but its greater size and less elongated body denote a more generalised form.

Distinguishing characters:—The larger size, shorter and less hairy tail, shorter and more slender nose, and generally more striking, usually tricoloured, coloration, with the distinct pattern of the teeth, make the identification of the Common Shrew an easy matter. The characteristics of the Pygmy Shrew will be given under heading of that species.

The small size, quite as much as the retiring habits of the Common Shrew, makes observation of its movements difficult.[1] Its long and pointed snout, flexible form, and compact velvety coat, enable it to pass through the closest herbage, or beneath the carpet of dry leaves in the coppices and woodlands, in which situations, as well as in the open fields, whether of grass or tillage, it seeks its food. Its habit is to pass into or through any crevices or passages which may come in its way, and thus it probably avoids the construction of burrows on its own account.

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[1] See, however, Douglas English's *Some Smaller British Mammals*, Bousfield and Co., Ltd., London, undated. This little book contains a number of interesting photographs.

It is widely distributed over almost every kind of country, and would seem to be equally at home on plain or mountain, and it is, besides, occasionally a climber of trees.[1] Unfortunately, in many cases where individuals have been met with at high altitudes, the species has not been carefully noted. Thus George Sim is responsible for the statement that the Common Shrew occurs upon the summits of the highest mountains of the Dee area in the north-east of Scotland, but his observations lack precise value from the fact that he does not mention the Pygmy Shrew in his book. Again, though it was known that shrews had frequently been caught by the cats at the observatory on the summit of Ben Nevis, it was left to Colonel H. W. Feilden to record[2] the fact that one at any rate of the victims was a Pygmy Shrew, so that it is still uncertain whether the present species reaches the summits of our highest mountains. We have, however, the authority of Messrs W. Eagle Clarke and W. Denison Roebuck, that it ranges to 1300 feet in Yorkshire, and we know that in continental Europe shrews ascend to at least 6000 feet,[3] and in Norway to the snow-line, so that the Common Shrew is probably one of the most widely distributed, abundant, and hardy of our British mammals.

Mr Rope,[4] who has remarked on its semi-aquatic habits, has found its nests by the sides of ditches, and in such cases the occupants when disturbed have often taken to the water, swimming with great ease. On one occasion, after a sudden flood, he found numbers of them on small islands, where in some places only the broken-down stems of the reeds were left unsubmerged. About these the shrews were running with remarkable activity and at times they seemed to be actually treading upon the surface scum, which, with a few floating odds and ends, was sufficient to support their weight. Mr A. H. Cocks writes me that he once received a specimen which had been caught by a man while bathing.

Despite many assertions to the contrary, shrews are active in winter, especially in the daytime. Even in Siberia, as shown by the American naturalist, Mr N. G. Buxton,[5] they do not

[1] G. T Rope, *Zoologist*, 1886, 26.

[2] *Ann. Scott. Nat. Hist.*, 1897, 42.

[3] *Fide* Blasius.

[4] *Zoologist*, 1873, 3525.

[5] *Bull. Amer. Mus. Nat. Hist.*, 31st March 1903, 182.

hibernate. It is probable that a spell of snowy weather is quite the best time for trapping them,[1] and during the great frost of 1895, when snow remained so long upon the ground, Mr G. H. Caton Haigh constantly caught both this and the smaller kind. Sim's "composite" species was seen by one of his informants to take shelter under a small patch of snow on the summit of Ben Muich Dhui, and I have examined specimens taken in midwinter in Skandinavia, at which season Dr N. F. Ticehurst found them quite lively. Occasionally in the cold season both the present and the succeeding species enter and ascend the dwelling-houses[2] of man, and they have secure underground winter retreats; but whether or no they dig them for themselves, as MacGillivray thought, is not certainly proved. They certainly spend much of their time in the runs and burrows of mice, and their weak claws are not suitable for extensive excavations. But like other mammals no better equipped, they are probably capable of digging when necessary. In summer they forage far afield over open country and may be found in any low-growing vegetation, but in winter they retire to the shelter of hedgerows, where they live largely in holes, in crannies, and in cracks of walls. In such quarters, by the help of the elongated and mobile snout carrying the prominent nostrils at its extremity, they search out the hibernating insects and their eggs, which, according to Professor R. Collett, are their main food at that season.

Although frequently found abroad by day, the Common Shrew is probably at least equally a creature of the night. It is, indeed, so voracious and its hunger so ungovernable that it must work hard to satisfy the calls of its appetite.

Its food consists largely of insects, worms, and small invertebrates generally, of which it consumes great quantities. It eats molluscs, both small and big, as observed by R. F. Tomes,[3] who fed captives with them; he also found the fragments of small shells[4] in its runs, and took the remains of a slug[5] from its stomach. There can be no doubt too that under pressure of hunger, it will attack less ignoble game, such as young frogs. These, as well as lizards, small birds and their eggs, and mammals, are included in its dietary by Victor Fatio and Monsieur Henri Gadeau de Kerville. The latter observation has often been corroborated by trappers of the smaller mammals, whose captures are constantly subjected to attacks, and in Norway it damages snared willow-grouse and is never absent from fish-curing stations (Collett). Shrews cannot resist carrion of any sort. In consuming mice, they sometimes turn the skin inside out, after the manner of a cat with a rabbit;[1] but Mr L. E. Adams finds that the almost invariable rule is to begin the meal at the upper ribs, eat into the carcase, and finish at the brain. Leonard Jenyns declared that they relish vegetable matter, and Charles St John stated[2] that they will bark trees; but no corroboration of these statements has been forthcoming in recent years for Britain; their tastes certainly descend to cheese, bread, aniseed, and even nuts when used as a bait.

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[1] See also William Evans, p. 27.

[2] *Fide* Millais; Gadeau de Kerville; J. H. Gurney, *Zoologist*, 1879, 123; according to Collett, many enter the houses in Norway in autumn and winter.

[3] In Bell, ed. 2.

[4] *Vitrina pellucida* and *Zonites*.

[5] *Agriolimax agrestis*.

It is certain that they much prefer a diet of living things, but animals which thrive right up to the North Cape, in Norway, and are active throughout the Arctic winter, can hardly afford to be particular about what they eat, and Professor Collett remarks that in Norway they eat soft vegetable food when occasion arises, and can be caught with apple or greenstuff as a bait.

American naturalists describe their "shrews" as being about as omnivorous as any creatures could well be, their diet varying from mice, which they take a special pleasure in killing, to grain when no other food is available. These remarks, however, refer more particularly to the Short-tailed Shrews or Blarinas,[3] the habits of which are better known in America than are those of the Soricidæ representing our own species. But, since in their appetites the smaller shrews differ from the larger only in so far as they are affected by lesser size and weaker power, all may be expected to have similar propensities. Dr C. Hart Merriam observed a captured Blarina of 11.20

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[1] N. B. Kinnear.

[2] *Natural History of the Highlands;* the trees could only have been very young ones.

[3] Genus *Blarina.*

grammes weight tire out, kill, and partially devour a mouse weighing 17 grammes. The killing and subsequent meal occupied a full hour.[1]

Mr Rope[2] has observed that shrews tunnel rather frequently in dry cow-dung, no doubt for the purpose of eating the invertebrates which find their sustenance in it. In captivity their appetite is so remarkable that it seems to merit a special paragraph, and will be described below.

This animal, like the Mole, is very pugnacious, especially in the breeding season,[3] so that it is rare to see two of them together except in the act of fighting or pairing. Mr J. G. Millais once discovered a pair locked in the embrace of mortal combat, and Mr T. A. Coward has found fur in the mouths of dead shrews, which, judging by their wounds, must have perished while fighting. When moving about they frequently utter a series of shrill squeaking cries, which, like those of bats, are not clearly audible to everyone, and which probably indicate a highly nervous and excitable disposition. Sometimes they turn to pursue a comrade, and, if battle be refused, the resulting chase is conducted in leaps of fully two feet each. The best description of their voices which I have seen was penned many years ago by John Wolley, who wrote that the "low sibilous notes may not inaptly be called whispering."

The irascible nature of the Shrew is even more manifest in captivity; no box is large enough to contain two of them at peace, and one will fight with any other creature of about its own size.

If two be confined in a box together, a very short time elapses before the weaker is killed and partly devoured, the victor not hesitating to tear out the intestines of the vanquished. C. A. Witchell[4] has described the fury of a captive which, having disembowelled a comrade, attacked with equal ferocity snakes, slow-worms, and vipers, from an unequal conflict with which it was removed unhurt in body and unsubdued in spirit.

"A duel between Shrew-mice," writes Mr English, "is, as might be expected from their strenuous nature, worth watching. The commencement on both sides is circumspect. The combatants advance, squeaking, with wide-open jaws and snarling muzzles, squirm round each other, jump clear across each other and at each other. Their jumps, from all four feet, are, considering the shortness of their legs, extremely neat and vigorous. Finally, one or the other gets a hold, often on his opponent's tail, and here the real business begins. They fasten head to tail and tail to head, and spin as a living ball, until the spin itself releases them. After a few seconds' rest, during which they are often lying on their backs squeaking defiance, a second round commences, and after that a third, and fourth, and fifth. I have never witnessed a duel which terminated fatally; but with well-matched adversaries, it must be a prolonged affair, ending only in the complete exhaustion of one or the other combatant."

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[1] *Vertebrates of the Adirondack Region*, 69-70.

[2] *Zoologist*, 1886, 26.

[3] At this season both males and females show signs of conflict, particularly about the feet and tail, which are often quite denuded of hair and covered with wounds (Adams, *op. cit.*, *infra*, p. 108).

[4] *Zoologist*, 1883, 293-294; *Fauna and Flora of Gloucestershire*, 1892, 9-10.

In spite, however, of their unenviable temper, these little creatures afford interesting material for observation, but I am unaware of their having survived capture longer than a few months, and that period only under the care of Mr Cocks or Mr English. They never become sufficiently advanced in the rudiments of domesticity as to merit the title of "pet." Hunger soon drives them to take worms or insects from the hand, and they become so far "trained" as to associate certain regularly repeated noises with feeding time. But this action must not be regarded as an indication of docility, but rather as a mere blind submission to an uncontrollable desire for food. This imperishable hunger is, in truth, the greatest obstacle to their health in confinement, for a lavish supply of food must be kept ready for them by day and night, if they are not to die of starvation.

Several naturalists have published their experiences of the demeanour of the Common Shrew while in captivity. Amongst these Mr English's recently published observations should be read by every one interested in British mammals. He states that shrews, when they are really thirsty, drink with a curiously bird-like action. The snout describes a small arc in the water, and, at the end of its sweep, points almost perpendicularly upwards.

One possessed for a fortnight by Mr Henry Barclay[1] would eat two or three dozen cockroaches in a night, seizing them behind the head and devouring from thence backwards all except the hard portions of the legs and wing-cases. In its habits it was very active, always on the move, and usually making a shrill squeaking noise while hunting for food. When frightened it emitted a disagreeable musky smell.

E. R. Alston[2] kept a Common Shrew for a few days in a box with moss, and observed that it seized house-flies with a spring, eating seven or eight at a time; if more than that number were given to it, it hid them amongst the moss in its box. "Small worms were caught by one end and munched slowly without being bitten through. On giving it a large one (about four or five inches long) it gave it a sharp bite, then sprang back, then flew at it again, until the worm was half-dead, when it ate about half and hid the rest. It slept during the middle of the day, rolled up among the moss, but always waked up at once if worms or flies were put into the box." Alston believed that "when pressed for food, shrews will kill and eat frogs, but when a large one was placed in the box the present specimen did not seem inclined to prey upon it, although now and then it gave it a slight bite on the hind leg; after they had been together for some hours the poor frog was taken away. The shrew seemed to be very cleanly, constantly dressing its fur and 'washing' its face with its fore-paws, as rabbits do."

The late Mrs Eliza Brightwen also wrote[3] a very entertaining account of a shrew which made for itself, inside the glass globe in which it lived, a domed nest with three entrances and covered runs. It was so voracious that "a full-grown mouse will barely supply enough food for . . . four-and-twenty hours."

Anyone who wishes to amplify the above observations can easily do so, since this Shrew is one of the most easily trapped, and perhaps the most universally abundant of all our small mammals, in this respect vying with small rodents and coming to almost any bait.[4] It seems to have no fear or suspicion of a trap, which, in fact, at least in my own experience, is likely to be very successful if placed in the most open and conspicuous position available.

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[1] *Zoologist*, 1848, 1957.

[2] *Journ. cit.*, 1864, 9358-9359.

[3] *More About Wild Nature*, 1892, 3-10.

[4] R. I. Pocock has used plum pudding.

It is an old observation often repeated, that dogs and cats, although they kill, will not readily eat the Common Shrew, and their aversion may probably arise quite as much from the early putrefaction undergone by a shrew carcase, as from the rank musky odour which the species possesses. This odour, although not usually emitted except under the influence of fright, may also have been in some measure the cause of the ancient prejudices concerning its supposed power of inflicting injury by the mere contact of its body. On the other hand, examinations of the "pellets" or regurgitations of owls and other birds have long since[1] established the fact that they make no such nice discriminations, and that they destroy numbers of shrews; and it is certain also that carnivorous mammals will occasionally eat them.

The unfortunate creature was formerly the centre of a whole host of extravagant superstitions, which, like all ignorant prejudices, disappear but slowly from our midst, and probably still linger in the more inaccessible parts of the country. Its very name is an indelible brand of malignancy and spite, and must have owed its existence to centuries of misapprehension in many lands. From the time of Aristotle, who declared that its bite is dangerous to horses and other draught animals, and produces boils,[2] its presence has been regarded as something peculiarly noxious, so that a variety of the most extraordinary remedies and preventatives occur in the works of ancient writers. In England it was believed by running over an animal to produce lameness and even disease. Thus it was described in an old book[3] as the "Shrew or Shrew-mouse, a kind of Field-Mouse of the bigness of a Rat and colour of a Weasel, very mischievous to Cattel, which going over a Beast's Back, will make it Lame in the Chine; and the Bite of it causes the Beast to swell to the Heart and die." But the poor creature's fair name was never, I suppose, more foully besmirched than by Edward Topsel, who spared no details in his description of its crimes.

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[1] Pellets seem to have been first examined by Henry Turner, of the Botanic Garden at Bury St Edmunds, who published his conclusions in 1832 (see Loudon's *Mag. Nat. Hist.*, v., 727). Adams had a dead shrew brought to him from a magpie's nest, and has known trapped specimens to be eaten by *Evotomys*. J. E. Harting took one from the stomach of a stone curlew (*Vermin of the Farm*, 1892, 22).

[2] *Historia Animalium*, viii., 24, D'A. W. Thompson's ed., 1910, 604^b, 19. For Holland's translation of Pliny and Somner's version, see above, p. 85.

[3] *New World of Words: or, Universal English Dictionary*, 6th edition, London, 1706, a revised version of *The Moderne World of Words, or a Universal English Dictionary*, collected from the best authors by E. P. (Edward Phillips: 1st ed., 1696).

"The Shrew," he wrote, "is a ravening Beast, feigning it self gentle and tame, but, being touched, it biteth deep, and poysoneth deadly. It beareth a cruel minde, desiring to hurt any thing, neither is there any creature that it loveth, or it loveth him, because it is feared of all. The Cats, as we have said, do hunt it and kill it, but they eat not them, for if they do, they consume away in time. They annoy Vines, and are seldom taken, except in cold; . . . . If they fall into a Cart-road, they die and cannot get forth again, as *Marcellus*, *Nicander*, and *Pliny* affirm. And the reason is given by *Philes*, for being in the same, it is so amazed, and trembleth, as if it were in bands. And for this cause some of the Ancients have prescribed the earth of a Cart-road, to be laid to the biting of this Mouse as a remedy thereof. They go very slowly, they are fraudulent, and take their prey by deceit. Many times they gnaw the Oxes hoofs in the stable. They love the rotten flesh of Ravens; and therefore in *France*, when they have killed a Raven, they keep it till it stinketh, and then cast it in the places where the Shrew-mice haunt, whereunto they gather in so great number, that you may kill them with shovels. The *Egyptians* upon the former opinion of holiness, do bury them when they do die. And thus much for the description of this Beast. The succeeding discourse toucheth the medecines arising out of this Beast; also the cure of her venomous bitings."

Only one or two examples may be quoted from this truly devilish pharmacy. Thus:—

"The Shrew, which falling by chance into a Cart-rode or track, doth die upon the same, being burned, and afterwards beaten or dissolved into dust, and mingled with Goose grease, being rubbed or anointed upon those which are troubled with the swelling . . . doth bring unto them a wonderful and most admirable cure and remedy. The Shrew being slain or killed, hanging so that neither then nor afterwards she may touch the ground, doth help those which are grieved and pained in their bodies, with sores called fellons, or biles, which doth pain them with a great inflammation, so that it be three times invironed or compassed about the party so troubled. The Shrew which dyeth in the furrow of a Cart-wheel, being found and rowled in Potter's clay or a linnen cloth, or in Crimson, or Scarlet woolen cloth, and three times marked about the Impostumes, which will suddenly swell in any man's body, will very speedily and effectually help and cure the same.

"The tail of a Shrew being cut off and burned, and afterwards beaten into dust, and applyed or anointed upon the sore of any man, which came by the bite of a greedy and ravenous Dog, will in very short space make them both whole and sound, so that the tail be cut from the Shrew when she is alive, not when she is dead, for then it hath neither good operation, nor efficacy in it."

And again:—"There is a very good remedy against the bitings of Shrews, or to preserve Cattle from them, which is this; to compass the hole wherein she lyeth round about, and get her out alive, and keep her so till she dye, and wax stiffe, then hang her about the neck of the Beast which you would preserve, and there will not any Shrew come near them; and this is accounted to be most certain."

The use of a well-known ancient antidote to these imagined injuries has now passed away; it consisted in the application of a twig of a shrew-ash, of the preparation of which Gilbert White[1] gives the following account:—

"At the south corner of the *Plestor*, or area, near the church, there stood, about twenty years ago, a very grotesque hollow pollard-ash, which for ages had been looked on with no small veneration as a *shrew-ash*. Now a shrew-ash is an ash whose twigs or branches, when gently applied to the limbs of cattle, will immediately relieve the pains which a beast suffers from the running of a *shrew-mouse* over the part affected: for it is supposed that a shrew-mouse is of so baneful and deleterious a nature, that wherever it creeps over a beast, be

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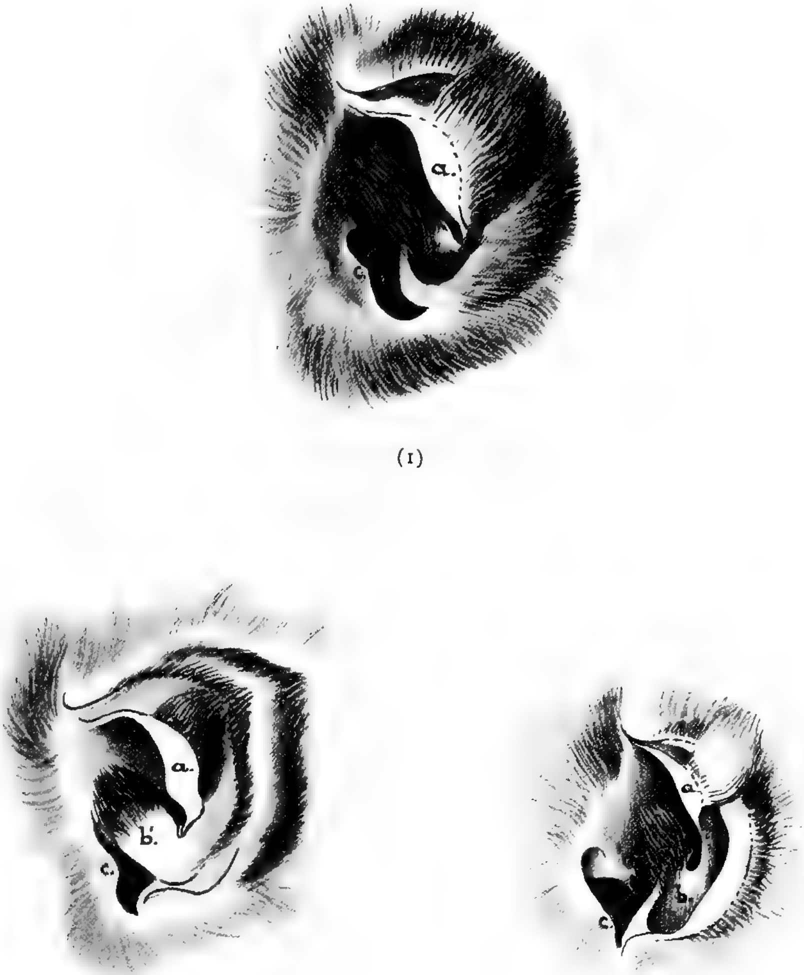
[1] Letter xxviii. to Daines Barrington, 8th January 1776.

PLATE VI.



(1)

(2)

(3)

Left Ears of (1) Common Shrew (5 times life-size); (2) Pygmy Shrew (7 times life-size); and (3) Water Shrew (4 times life-size), the latter with tuft of white hair on superior valve (*a*). The lobes for closing the ear are marked—*a*, superior; *b*, antitragial; and *c*, small tragial.

it horse, cow, or sheep, the suffering animal is afflicted with cruel anguish, and threatened with the loss of the use of the limb. Against this accident, to which they were continually liable, our provident fore-fathers always kept a shrew-ash at hand, which, when once medicated, would maintain its virtue for ever. A shrew-ash was made thus:—Into the body of the tree a deep hole was bored with an auger, and a poor devoted shrew-mouse was thrust in alive, and plugged in, no doubt, with several quaint incantations long since forgotten."[1]

Another cure was to make the shrew-struck person or animal pass through the arch of a bramble, both ends of which were rooted and growing; and in Cheshire the small twigs and young boughs of a shrew-ash were gathered and hung on the roof over cows before calving-time.[2]

The genital organs begin to become functional in February, and the rutting season commences in March, before which month the sexes are difficult to distinguish even by dissection. It is probable that the soft passion incites to much pugnacity, since Mr Millais has noticed that the fighting season begins in March. According to Professor Collett, a pairing female may be pursued by several males, and the chase is productive of much squeaking.

The length of the period of gestation is unknown, but it is not likely that it differs widely from that of the Water Shrew.

The blind and naked young, which may reach ten in number,[3] are born in every month from April, although rarely in that month, to late November, Mr Oxley Grabham having met with a family of five half-grown young on the 1st October, and Mr Archibald Thorburn a nest as late as the 19th November.[4] The varied dates suggest the probability that second or even third litters, follow the first at rapid intervals, for there is as yet no evidence that the young breed during their first summer.[1] The nursery,

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[1] For a similar practice, see Plot's *Staffordshire*, 222.

[2] J. F. Robinson in the *Manchester City News* of 30th June 1883, as quoted by Coward and Oldham.

[3] See *Zoologist*, 1896, 432. Adams found 10 embryos (twice), 9 (once), 8 (six times), 7 (four times), 6 (once), 5 (once) 4 (twice), and 2 (once), in eighteen pregnant females. The average works out at exactly 7.

[4] In Millais. Adams has captured recently impregnated females on 21st November (*op. cit.*, *infra*, p. 108).

"A wee bit heap o' leaves and stibble,
Which costs it mony a weary nibble,"[2]

is most frequently found in hayfields at mowing time.[3] It consists of soft herbage, dried grass, and withered leaves, and is placed in some hole or depression in the open ground, in a tuft of grass, under a heap of sticks, or upon a bank. It is usually described as resembling that of the Harvest-mouse and having a round, cricket-ball-like appearance without visible hole for entrance or exit, such movements being quite easily executed through the yielding walls, which, being drawn together again, tell no tales. Mr Adams, however, on careful examination of three nests, found that they were in reality cup-shaped. The roofs lay loose upon them and could be removed without injury. The occupants could slip out all round by passing between the roof and the cup, and this formation makes the statement more intelligible that even when the top has been shaved off by a mower, or the nest has been otherwise disturbed, the mother does not readily desert her young, but re-covers the nursery with grass; sometimes, however, she is said to remove the family to a new site. A fourth nest examined by Mr Adams was not so carefully constructed, being a mere ball of bitten grass. Mr William Evans sends me a note of an exceptional nest found near Dunbar by Mr G. Pow, which was placed in a young spruce fir, at about three feet from the ground, and formed entirely of thistledown. It contained a dead shrew. Mr H. E. Forrest reports a nest in a bee-hive which contained two old shrews and eight young ones.

The increase of the species which such a numerous progeny might be calculated to produce, is counterbalanced, not only by the destruction wrought amongst them by the agency of other mammals and by birds, but by a very general and mysterious mortality. This is most commonly observed in the autumn, but prevails also in summer and even in spring. Its cause does not appear to be thoroughly understood. So many shrews may be found lying dead on footways, or other bare ground near their haunts, as to have led to the belief mentioned above among country people, that one cannot cross a public way without incurring instant death. This mortality, as Tomes[1] was able to satisfy himself, extends to individuals of both sexes and of all ages. It is naturally more perceptible on roads or bare places, but if, as has been suggested, it is no less severe in woods and tall herbage, where it is necessarily impossible to appreciate its extent, then its magnitude must indeed be enormous. It is also associated with the two other British species, the Pygmy and Water Shrews, and must, therefore, be due to causes which affect all three alike.

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[1] Suckling females are heavily coated over the abdomen with glandular fat (Adams, MS.).

[2] As aptly quoted by J. J. Briggs, who has placed on record some interesting details; see *Zoologist*, 1848, 2280.

[3] Some of the nests reported may have been built for dormitories, and not nurseries, as it does not seem to be known exactly how shrews sleep. They certainly construct sleeping nests in captivity.

Several plausible explanations have been put forward to account for this mortality. It has been attributed to sexual excitement[2] leading to wandering recklessness, and consequent capture by predatory animals,[3] but, if that be so, it is difficult to understand why marks of violence upon the carcases are comparatively rare, and further, why they are left uneaten, since, as already shown, shrews are not always refused by beasts and birds of prey.[4] MacGillivray connected it with drought,[5] resulting in scarcity of food, a suggestion only tenable had we evidence that the autumnal mortality is greater in countries of dry than in those of moist climate.

The late Robert Service, after examining some hundreds of wayside shrew carcases,[6] wrote me that he had formed the belief that, in the neighbourhood of Dumfries at least, the Hedgehog is the principal cause of shrew mortality. But that this cannot be so is shown by the fact that Mr Millais observed Lesser Shrews lying dead on a worn trail in North Uist, as I have myself noticed the Pribiloff Island Shrew on St Paul's Island, Alaska, in autumn, and on neither island do hedgehogs occur.

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[1] In Bell, ed. 2.

[2] J. L. Knapp, *Journal of a Naturalist*, ed. 2, 1829, 145.

[3] Jonathan Couch, *Illustrations of Instinct*, 1847, 279.

[4] They are killed by cats, and occasionally by dogs, but rejected by most beasts of prey. They are devoured by a few birds of prey, especially by Common and Rough-legged Buzzards, and by most of the owls, but not in numbers (Collett).

[5] From this Adams believes that small rodents escape by migration.

[6] See article on Hedgehog, p. 67.

A remarkable suggestion is that of Mr English, who, as quoted by Mr Millais, having observed that shrews die very readily, as, for instance, on the snapping of a trap by which they are themselves untouched, thinks that they may perish during thunderstorms or when the atmosphere is in an unsettled thundery state. Such a suggestion is one of those which is more easily advanced than substantiated, but, strange as it may seem, it cannot be regarded as absolutely unfounded on fact. I can myself corroborate the fact that a shrew may die on the mere snapping of a trap, and Mr F. G. Aflalo suggests, on plausible grounds, that they succumb readily from fear.[1] Many certainly perish in combats with adversaries no more terrible than their own species, and it may indeed be possible that a thunderstorm should occasionally affect them fatally.

Mr Cocks has pointed out to me that, as already stated, the Common Shrew is probably by far the most numerous mammal in the British Isles, as it is also, according to Professor Collett,[2] in Norway; and all the shrews are very prolific, so that the three species aggregated must total a vast multitude, of which many more must die each year than of any other mammal or group of mammals.

Anyone who has watched the gait of shrews of any species at close quarters, as in captivity, through glass, cannot fail to have been struck with the extreme feebleness displayed. They totter in every movement, exactly as if they were suffering badly from rickets; their legs barely support their weight, and they continually stumble over the slightest obstruction, such as a small bit of moss or grass, so that in the case of a freshly-caught individual one can hardly persuade oneself that one of its legs is not broken.

The instinct of any animal on finding itself ill in any way, is to hasten to some hiding place, where the dead body is in a great majority of cases not found; but the least accident of any kind (including, as suggested above, a clap of thunder, or the snapping of a trap, which have no effect on larger animals) may be instantly fatal to these frail little creatures, leaving them no time to hide. Mr Cocks therefore thinks that the fatality may be caused by a multitude of different agencies, not one or other only of those already mentioned. Dead shrews are undoubtedly found now and then bearing the tolerably obvious marks of the beak of an owl; the singles of an owl, on catching so small an animal, may very often encircle the body without making any visible holes, but when the prey has been transferred to the bird's beak, the nip is left tolerably plain. If an owl saw any small rodent, it would perhaps drop the insectivore to pursue the more choice morsel.

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[1] *Field*, 13th August 1898, 279.

[2] "Norges vigtigste Hvirveldyr," in *Norge i det Nittende Aarhundrede* 1900, p. 85.

Again, in the case of other animals dying in the open, as they "keep" for some time (depending of course on the species, the temperature, and the degree of dampness), there is a chance of the body being found and eaten or dragged into concealment, by some meat-eating mammal or bird, to which, even when "high," they are palatable. But a shrew, as previously stated, almost immediately becomes so unpleasantly putrid, that no animal, unless exceptionally hungry, cares to touch it.

Everyone has met with cases where rabbits and rats are found surviving, and in a fair way to recover from, extremely severe wounds; for instance, it is nothing uncommon to find a rat suffering from a suppurating wound caused by a stab from a pitchfork. Among many other cases may be mentioned a rabbit quite recently killed near Henley-on-Thames during the cutting of a field of oats, which had evidently, several days previously, lost three of its legs by the knives of a binder. It was quite lively, and not at all meaning to die, but there is no doubt that a far less proportionate injury would be instantly fatal to shrews.

Further light is undoubtedly thrown on the whole matter by the studies of Mr Adams, who concludes that the entire adult shrew population perishes each autumn. The evidence in support of this conclusion, which has recently been published, is based on examination of specimens throughout the year, and is so strong as to be nearly incontrovertible. It has further been supported by numerous more recent, and still unpublished, observations by Mr Adams, all of which he has most kindly placed at my disposal. Amongst forty-eight Pygmy and three hundred and ten Common Shrews captured after December, there was not a single adult of either sex, and not a single female that had already bred. Consequently, according to Mr Adams, the autumnal "epidemic" is due to nothing more than old age; old age in the case of the Common and Lesser Shrew being reached in, roughly, thirteen or fourteen months.[1]

To show that the proportions of adults and juveniles actually vary definitely according to season, Mr Adams has prepared a table showing the average size of shrews throughout the year. This has been summarised above on page 92, and bears out his conclusions in a very remarkable manner.

On the whole, it seems that there is probably more than one cause of mortality. It is not restricted to any one of our three British species. It may be, however, connected with the breeding season, and occasionally, at least, with some bad-tempered but not hungry assailant. Add to the above the known pugnacity and fragility of all three species, so well illustrated by the late John Cordeaux's observation of two male Water Shrews which fell in mortal combat and yet showed hardly a trace of their encounter,[2] and we have a handful of causes, any one of which—and there may be many others—might answer for many deaths, and that specially in summer when the countryside is crowded with young shrews all newly launched upon a thickly-populated world, and ready victims in the struggle for existence amidst the changing conditions of food supply and atmosphere.

A remarkable feature of the natural history of the present species is its, at least occasional, habit of congregating in numbers on one small area. Thus, Mr W. N. McCartney, more than thirty years ago, recorded[3] his observation in May of "between one hundred and one hundred and fifty shrew mice running nimbly about, uttering their peculiar sharp cry . . .

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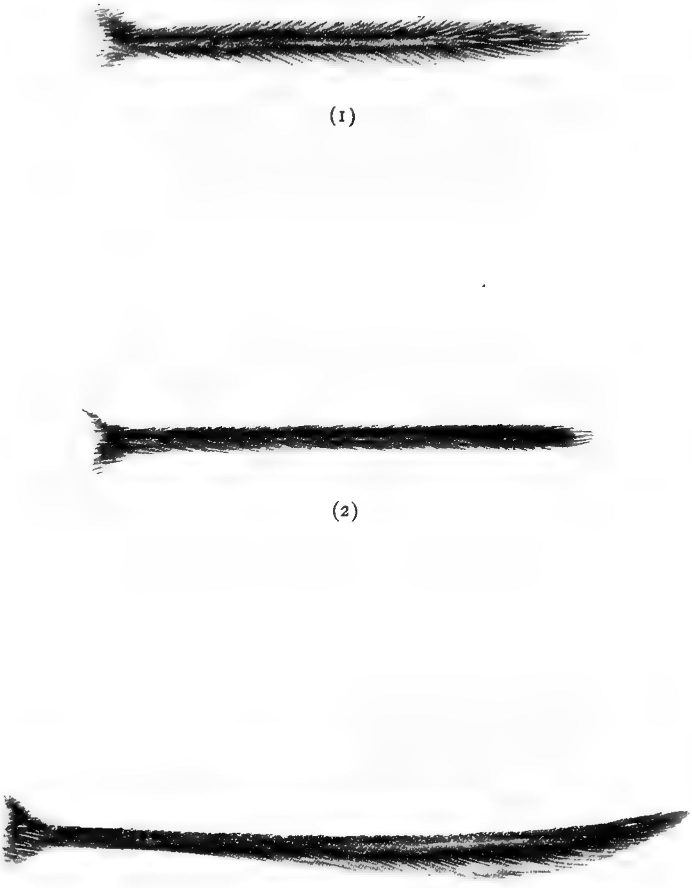
[1] See "A Hypothesis as to the cause of the Autumnal Epidemic of the Common and the Lesser Shrew, with some Notes on their Habits," in *Mem. and Proc. Manchester Lit. and Philosoph. Soc.*, liv., 10, 1-13 and plate, read 8th February 1910; also comments by C. B. Moffat, *Irish Naturalist*, 1910, 121-126.

[2] See below under Water Shrew.

[3] *Zoologist*, 1861, 7624.

PLATE VII.



TAILS OF (1) LESSER SHREW, (2) COMMON SHREW, AND (3) WATER SHREW.
(All viewed from side; magnified 1½ times.)

chasing and calling on one another." Again, Mr F. Longman has recently recorded a congregation estimated to include nearly one hundred shrews.[1]

There is some evidence that shrews occasionally, at least, combine to travel and hunt their prey in "packs," after the fashion of the stoats and weasels. Mr H. J. Charbonnier, for instance, has observed the present species travelling in small parties of eight or ten, the individuals scattered over a few yards, but all heading in one direction, and a similar record is that of the late Canon H. B. Tristram,[2] who met with nine or ten Water Shrews hunting on the path of a plantation, a mile from water, and it can hardly be doubted that these were family parties of parents and offspring.

It cannot be denied that the habits of the Common Shrew render it an animal beneficial to the farmer and gardener, and in every way worthy of protection.

THE PYGMY OR LESSER SHREW.

SOREX MINUTUS, Linnæus.

1766. SOREX MINUTUS, Carolus Linnæus, *Systema Naturæ*, xii., 73; described from Jenesei River, Siberia; Alston, *Fauna of Scotland*, 1880, 10; Thomas, *Zoologist*, 1895, 43; Lydekker; Beddard; Johnston; Millais; Trouessart (1910); Collett.

1769. SOREX PYGMÆUS, Erich Laxmann, *Sibirische Briefe*, 72 (ed. Schlözer); described from Barnaul, Tomsk, Western Siberia, 17th November 1764; Pallas, *Zoographia Rosso-Asiatica*, i., 134-135, tab. x., fig. 4, 1811; Blasius; Fatio; Bell (ed. 2); Woodward and Sherborn; Flower and Lydekker; Winge.

1774. (?)SOREX PUSILLUS, S. G. Gmelin, *Reise durch Russland*, iii., 499, tab. lvii., fig. 1; described from Persia; Zimmermann, *Geographische Geschichte des Menschen*, etc., 1780, ii., 385, sp. 317; Blanford, *Eastern Persia*, 1876, ii., 25-26.

1780. SOREX MINUTISSIMUS, E. A. W. Zimmermann, *op. cit.*, 385, sp. 319.

1788. (?)SOREX CÆCUTIENS, Erich Laxmann, *Nova Acta Acad. Sci. Imp.* (St Petersburg), iii., 285, 12th May 1785; described from Lake Baikal; = *S. pygmæus* of Pallas; see Pallas, *loc. cit.*, *supra.*

1788. (?)SOREX EXILIS, J. F. Gmelin, *Systema Naturæ*, i., ed. 13, 115, sp. 11; described from the Jenesei River, Siberia.

1806. SOREX CANALICULATUS, S. I. Ljungh, *Kongl. Vetenskaps Akademiens Nya Handlingar* (Stockholm), xxvii., 263; described from Lommaryd Vicarage, Northern Vedbö district, Jönköping, Sweden.

1811. (?)SOREX GMELINI, P. S. Pallas, *Zoographia Rosso-Asiatica*, i., 134, tab. x., fig. 3; renaming *S. pusillus* of S. G. Gmelin from Persia; Blanford, *op. cit.*, 1876, 26.

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[1] *Field*, 4th July 1908, 4.

[2] *Zoologist*, 1853, 3905.

1811. SOREX MINIMUS, Isidore Geoffroy, *Ann. du Mus. d'Hist. Nat.* (Paris), xvii., 186; renaming *S. minutus* of Linnæus.

1832. (?)SOREX PUMILIO, J. Wagler, Oken's *Isis* (Jena), 54; described from Bavaria; see Nathusius in Weigmann's *Archiv für Naturgeschichte*, 1838, i., 19-47.

1838. SOREX RUSTICUS, Leonard Jenyns, *Ann. Nat. Hist.*, i., 423; described from England; MacGillivray, appendix, in error.

1838. SOREX RUSTICUS, var. β, S. HIBERNICUS, Leonard Jenyns, *loc. cit.*; described from Dublin, Ireland.

1842. AMPHISOREX PYGMÆUS, G. L. Duvernoy, Guérin's *Mag. de Zool.*, 30, pl. 48.

1843. CORSIRA RUSTICA, J. E. Gray, *List of the Specimens of Mammalia in the Collection of the British Museum*, 79; Abbey, *The Balance of Nature*, 1909, 5.

1844. SOREX PUMILUS, S. Nilsson, *Öfversigt af Kongl. Vetenskaps-Akad. förhandlingar* (Stockholm), i., 33, 20th March; described from North-Eastern Skaane, Sweden.

1890. HOMALURUS PYGMÆUS, E. Schultz, *Schriften des Naturwissenschaftlichen Vereins des Harzes* (Wernigerode), v., 28.

La Musaraigne pygmée of the French; *die Zwergspitzmaus* of the Germans.

The plan of the **synonomy**, which is comparatively simple, is similar to that of *S. araneus*. *Minutus*, although overlooked until recent years, is undoubtedly the correct name for the European Pygmy Shrew,[1] at least until such time as the Pygmy Shrew of the Jenesei district may be shown to be distinct. Of the remaining names, some are pure synonyms, while others may prove to be applicable to local races or even to distinct species; *cæcutiens* was pronounced by Pallas, who examined Laxmann's specimens, to be identical with *pygmæus*, while *pumilio* has been similarly placed by Nathusius; *rusticus* and *hibernicus* were bestowed respectively upon the Pygmy Shrews of England and Ireland by Jenyns in days when these animals were very little known to naturalists. The species was well discussed by Gloger in 1827, *Nov. Act. Phys-Med. Acad. Cæs. Leop. Nat. Cur.* (Bonn), 483-498, coloured plate xxv. It first appeared in its proper status as a British mammal in Bell's second edition, the account of it which appeared in that work having been written by E. R. Alston. Further details of its history will be found below on pp. 116-117.

Local names:—See above, under Common Shrew, p. 85. Grass-mouse of Co. Fermanagh, Ireland (see Adams, *Zoologist*, 1906, 439; rone (=thicket) -mouse (see *Dial. Dict.*) of Orkney (Moodie Heddle).

Distribution:—The range of *S. minutus* is as yet imperfectly known, but it is found certainly throughout arctic, boreal, and transitional Europe, from sea-level to at least 5500 feet, as in Transsylvania; and from Ireland eastwards to the Altais (Kashtchenko), and the shores of the Pacific, including Korea, Kamchatka, Hondo, and

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[1] For a further explanation, see below, p. 117.

Sakhalin. In Skandinavia it is less numerous than *S. araneus*, but inhabits all parts of Norway as far north as the Varangerfjord (70° 5′ N. lat.), and ascends the mountains to the tree limit (Collett). It reaches at least 61° north latitude in Russia (Blasius); and according to Dobson, *Proc. Zool. Soc.* (London), 1891, 350, has been found within the Arctic circle at the Khatanga and Olenek rivers, in Siberia. Southwards it ranges to the Pyrenees (*not* in Spain, Cabrera), southern Italy (but not in the Balkan Peninsula, *fide* Miller), the (?)Crimea, the regions around the Lower Volga, (?)Persia (Mazandarán, Derband, etc.), and (?)Lake Baikal. It would appear to be everywhere less abundant and more sporadic than *S. araneus;* thus Blasius states that in Germany, of 200 shrews only 20 were *minutus*, or 9 *araneus* to 1 *minutus;* for Norway, Collett gives the corresponding figures as 210 and 7, or 30 *araneus* to 1 *minutus;* and Adams for a small district near Reigate, as 210 and 40, or 5·25 *araneus* to 1 *minutus.* The animal is so unevenly distributed that in a second district near Reigate the figures would be, according to Adams, 210 and 0, while those for specimens taken from owl pellets collected in many parts of England are 344 and 27, or nearly 13 *araneus* to 1 *minutus*, the latter item being considered by him too high for an average ratio throughout the country.

It is directly represented in America by the hardly distinguishable *S. personatus* of I. Geoffroy and allied forms, which are widely distributed from ocean to ocean in arctic, boreal, and transitional zones.

The Pygmy Shrew is probably of as wide distribution throughout the mainland of **Britain** as the previous species, but, as in continental Europe, it appears to be, as a rule, far less numerous, though its numbers seem to vary locally. Thus, although generally reputed to be rare, in certain of the hill cloughs of Cheshire it is as abundant as, or more so than, *S. araneus* (Coward, *in lit.*). It is common about Edinburgh, especially, as W. Evans believes, in the moorland districts, but Booth (*Zoologist*, 1911, 314) insists on its rarity in Yorkshire. It is of wide range amongst the islands, being the only shrew of **Ireland**, where it occurs in every county and on Clare, Rathlin (Adams, MS.), and Achill Islands (specimens in Dublin Museum caught by Alexander Williams); Man; the Outer Hebrides; and Orkneys. I have seen specimens, many taken by Kinnear, from Lewis, North Uist, Benbecula, South Uist, and Barra, indicating a very wide distribution in these islands; while in the Orkneys shrew mice were mentioned by Barry (1805) as found "but rarely," but were not properly identified until 1905, when Eagle Clarke trapped specimens at Stromness in Mainland (*Ann. Scott. Nat. Hist.*, 1905, 8); it is common at least in that island and South Ronaldshay, where it has been taken also by Godfrey and by Kinnear.

In the Inner Hebrides it is known at least from Skye (Steele Elliott); Eigg (Harvie-Brown and Buckley); Tiree (Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1898, 111); Sanda and Great Cumbrae (Boyd Watt); and Ailsa Craig (Kinnear, *Ann. Scott. Nat. Hist.*, 1907, 49). In the English Islands it is known from Anglesey (Coward); Wight (Wadham, Thomas); Scilly (Chubb); and Lundy; in the latter it is probably numerous, specimens having been shown me by Joy and by Coward and Oldham (see Coward, *Mem. and Proc., Manchester Lit. and Philosoph. Soc.*, lii., i., No. 6, 3-4, 10th December 1907, published 22nd January 1908).

It frequents the highest mountains of Britain to their summits, having been taken at the observatory on Ben Nevis, at an altitude of some 4400 feet (Feilden, *Ann. Scott. Nat. Hist.*, 1897, 42); on Longmynd, Shropshire, at over 1500 (Forrest, MS.); and in Coiynafearn deer forest, Inverness-shire, at 2000 feet (C. H. Alston, *Ann. Scott. Nat. Hist.*, 1909, 114).

Distribution in time and status:—Judging by its distribution, the Pygmy is an older species in Britain than the Common Shrew; but this is not as yet borne out by the facts at present available regarding its history in past geological times; for it is only known in Britain from the latest pleistocene deposits (Ightham fissures). The remains from the late pliocene Forest-Bed and other old deposits formerly assigned to it belong, as Hinton has shown, to extinct forms, and have nothing to do with *S. minutus*. In its dentition, its lesser size and its more elongated body, it seems to be more specialised than *S. araneus;* but its comparatively low plasticity—since it ranges in almost indistinguishable form throughout a vast area of continental Europe, Asia, and America—and the fact that it wears throughout life a pelage corresponding to that of the juvenile Common Shrew, certainly point to a more ancient species.

Description:—Although in general structure and appearance the Pygmy Shrew at first sight closely resembles the preceding species, it is smaller, relatively longer, as well as more finely built; has a longer, thicker, more hairy tail; the feet more slender, the outer toes longer and more heavily haired; and the snout more heavily moustached (whiskers reaching 16 millimetres), as well as relatively longer and thicker. The seasonal changes of colour and length of the fur are not nearly so marked as in *S. araneus*.

In the **hand and foot** the tip of the first digit reaches beyond the pad at the base of the second, and the tip of the fifth about half-way to the tip of the fourth (compare *S. araneus*, above, p. 87, and see Plate VIII., Figs. 1 and 2).

The **colour** of the upper side varies in winter between "hair brown" and some ruddier shade; the under side, including the inner surfaces of the legs and the under surface of the tail, is dirty white, with a moderately sharp line of demarcation passing from the angle of the mouth on each side to the shoulders, and thence along the flanks to the anus. The feet are near "wood brown;" the tail near "prout's brown," lighter beneath. In summer the upper side is of a tint between "drab" and "fawn colour," with the under side yellowish or brownish, lighter on the upper throat. The hidden basal portions of the hairs are always and at all seasons near "blackish slate," or darker.

The above description applies to preserved skins, but in life there is present on the fur an iridescence which leads English to style it as "unquestionably the most beautiful" to be found on a British mammal.

The **moults** of the winter and summer pelages appear to agree pretty closely with those of the Common Shrew, and there is the same irregularity in regard to date; the hairs of the tail are renewed in summer or autumn, leaving that organ temporarily very bare and the vertebræ prominent. I have seen specimens in this condition from Ireland in September, and others from South Ronaldshay, Orkneys, in August, the latter sent to me by Godfrey. On the other hand, August specimens from South Ronaldshay and Achill Island, Ireland, have the tail thickly haired, but these were probably young of the year, which Adams finds have always hairy tails.

In the much smaller and more fragile **skull** the brain-case is narrower and more elongated than in *S. araneus;* its outline, viewed from above, is distinctly oval, not circular. The unicuspids are characteristic, since they decrease in size with comparative regularity from front to back. Nos. 1, 2, and 3 are nearly equal, 4 is distinctly smaller than 3, and 5 is minute, although usually of relatively larger size and greater external visibility than in *S. araneus.* The posterior molar is large and projects behind the process of the malar bone, whereas in *S. araneus* it is so entirely concealed by that bone as to be usually invisible from the outside. In the first upper incisor the posterior lobe is relatively not so thick as in *S. araneus,* the length of its base being about half that of the anterior cusp; and in the first lower incisor the basal lobes do not diminish regularly in diameter from front to back, but the first is as well defined from the anterior point of the tooth as from the second lobe (Fig. 24, No. 2, p. 90); the gap between the first and second is not conspicuously the largest, as it is in *S. araneus.*

This species is much less subject to **individual variation** than *S. araneus.* Merriam and Miller (*North American Fauna,* No. 10, 1895), state that in the American Pygmy Shrew, *S. personatus,* a chestnut pelage or phase occurs, but is rare. This may possibly correspond to the rufous form of *araneus*, and should be looked for in *minutus*. Again, in some American specimens there is an approach to the tricoloured pattern of *S. araneus*, though not in a very pronounced degree.

Some specimens from Orkney and the north of Scotland are slightly darker than those from Britain generally, but the series of accurately prepared and measured specimens is too slight to form a basis for final conclusions, which must await the accumulation of a sufficient series from British localities.

Exceptional variation and sports:—Of white or albino Pygmy Shrews, one from Thetford, England, is in the possession of Bidwell (Southwell); a second is in J. Whitaker's collection (*Field*, 19th February 1910, 333); a third, a male from Brandon, Suffolk, taken in October 1910, belongs to Dalgliesh (*Zoologist*, 1911, 27). Of three from Ireland, the first, a cream-coloured example of large size, was taken in Kerry in 1840 (Thompson); the second is from Limerick (Daly, *Field*, 21st August 1897, 318); and the third, from Fermanagh, was in the possession of the late Sir Douglas Brooke.

Geographical variation:—The Pygmy Shrew seems to be comparatively lacking in plasticity, but Miller (*Ann. and Mag. Nat. Hist.*, May 1909, 415) has recently described a sub-species, viz., *S. m. lucanius*, from Monte Sirino, Lagonegro, Italy, with enlarged molars and anterior upper incisors. Gmelin's *S. pusillus*, from Persia, and Laxmann's *S. cæcutiens*, from Lake Baikal, may be large forms of *S. minutus*, and the same remark perhaps applies to Pallas's *S. gmelini*, also from Persia, but the description of the latter is so vague that the type specimen may actually have been some form of *Crocidura*. At the other end of the palæarctic region, Thomas's *S. m. gracillimus*, from Sakhalin, described in *Proc. Zool. Soc.* (London), 23rd April 1907, 408, from a fragment of one specimen, is said to present distinct skull characters. The same writer's *S. annexus* of Korea (*Proc. cit.*, 27th November 1906, 859), an animal of the size of *araneus*, and *S. shinto* of Hondo, Japan, a large form with long tail, with a sub-species *S. s. salvus*, larger in body and shorter in tail, in Hokkaido and Sakhalin, are also probably representative. A striking aberration from the type is Miller's *S. macro-pygmæus* of Kamchatka, which in size agrees with *S. shinto*. In this it seems to carry on the relationship to its nearest geographical neighbour of the group, Merriam's *S. personatus steatori* of Alaska, itself a large form of a type (i.e., *S. personatus*) which, ranging right across the American continent, is directly representative of and barely distinguishable from *S. minutus*. The resemblance is enhanced by the extremely slight tendency shown by *S. personatus* to vary with locality. A pale desert form is, however, known.

DIMENSIONS IN MILLIMETRES:—

	Specimens Measured in the Flesh.				Weight in grammes.
	Head and body.[1]	Tail without terminal hairs.	Hind foot without claws.	Ear.	
Males.					
One, Skye, Inner Hebrides (J. Steele Elliott)	55	36	10	..	..
One, Stornoway, Lewis, Outer Hebrides (Colonel Hawker)	47 (?)	38	11	..	..
One, Barra, Outer Hebrides, 21st May (N. B. Kinnear)	66	39	11	6·5	..
One, North Uist, Outer Hebrides, 13th June (N. B. Kinnear)	60	38	10	..	..
One, North Uist, Outer Hebrides, 28th June	55	41·5	11	6	..
One, South Uist, Outer Hebrides, 1st June	58	37	10·5	6·5	..
Two, Orkney, 26th and 30th May (N. B. Kinnear)	56·5	36	11	..	4·73
	58	38	11	..	4·54
Six, Orkney and Outer Hebrides (N. B. Kinnear), average	58·9	38·25	10·75	6·33	..
Twenty-eight, Reigate, Surrey (measured by L. E. Adams), Maximum	63	42	11·5*	7†	5‡
Average	56·6	39·4	10·8	6·7	5
Minimum	49	36	10	6	4·5
Females.					
One, Dalmeny, Linlithgowshire, Scotland, 4th January (N. B. Kinnear)	48	33·5	10·5	5	..
One, North Uist, Outer Hebrides, 19th June	55	..	10·5	6·5	..
One, Lewis, Outer Hebrides, 5th July	60·5	38·5	10	6·5	..
Six, Orkney (N. B. Kinnear), 28th May	54	37	11	..	4·03
30th ,,	59	35·5	10	..	4·41
31st ,,	56	38	11	..	5·79(contained 6 embryos)
9th Oct.	50	35·5	11	5·5	3·2
17th Nov.	53 and 54	36 and 41	11 and 11	4·5 and 4·5	..
Six, Orkney; two, Outer Hebrides; and one, Scotland (N. B. Kinnear), average	54·38	37·5	10·66	5·41	..
Twenty-four, Reigate, Surrey (measured by L. E. Adams), Maximum	62	45	11	7	6·1
Average	56·5	40	10·8	6·7§	4·6‖
Minimum	52	31	10	6	3
Sex Unknown.					
Sixteen, English and Welsh, dimensions from labels, average	64	37	10 to 11	6 to 7	..
Six, Scotland, average	51·75	40·5	10 to 11	6	3·65 (W. E. Clarke)
One, Lundy Island (Coward and Oldham)	55	41	11·5	..	..
One, Benbecula, Outer Hebrides (N. B. Kinnear)	60·5	38	10	6	..
One, Barra, Outer Hebrides (W. E. de Winton)	56	34	11	..	..
Eight, Isle of Man (taken and measured by C. H. B. Grant)	59·6	40	11·1	6·4	..
Ten, Ireland, average	59·3	36·2	10·95	..	..

[1] The snout may project 6 mm. beyond the incisors, which makes the head of a shrew proportionately long as compared with that of most other mammals.

* Once only. † 4 items only. ‡ 7 items only. § 3 items only. ‖ 7 items only.

There is no evidence to show that there is any constant sexual difference in dimensions. The most accurate measurements are those to which the names of the collectors are appended. Kinnear took a pair of scales to Orkney with the express purpose of weighing this mammal.

Skull:—Greatest length, 16; basal length in middle line, 13; palatal length in middle line, 6; length of upper tooth-series, 6·5; ditto of lower, 6; greatest breadth, 7 to 7·8; breadth at constriction, 2·5 to 3.

Proportionate lengths:—Tail (without end hairs), about ·65 to ·7 of head and body; hind foot about ·17 to ·18, and ear about ·1 of head and body.

The **weight,** when compared with that of the Common Shrew, shows that the Pygmy is a much lighter animal in proportion to its dimensions even than the measurements would suggest. Nine weighed by Adams in October 1910 averaged 5, with maximum of 6 and minimum of 4·2 grammes. The weight therefore is to the head and body length as 1 to 11, whereas in *S. araneus* it is about as 1 to 6; so that the average weight of each millimetre of head and body length is only ·11 as against ·6 grammes in *S. araneus.*

Adams finds that the weights and dimensions undergo a seasonal variation corresponding to that of the Common Shrew. He finds also that in such tiny animals the weight is seriously affected by the emptiness or fullness of the stomach, and even more so by advanced pregnancy.

The distinguishing characters have been given in some detail in the description. The smaller size, especially that of the foot, longer and thicker nose and tail, plainer coloration, and the size and pattern of the teeth are the most conspicuous.

The Lesser or Pygmy Shrew has until now been classed as the tiniest of British mammals, and in fact it is one of the smallest of the whole class. It is more minute than the Harvest-mouse, and even on the European continent only one non-volant mammal, also a shrew,[1] is more diminutive. It appears, however, that its weight is about the same as, or greater than, that of some of the smaller bats, such as the Pipistrelle, and possibly also the Whiskered. But the point must be left undecided until more accurate information becomes available. The extreme length of its body is no less characteristic than its diminutive size.

It is probably due to its small size that the Pygmy Shrew for so long escaped the attention of British naturalists. It was generally mistaken for the young of its larger congener, so that it remained until recently one of the least known of our terrestrial mammals, excepting only certain species of bats. All the earlier writers, such as Pennant, Bingley, Donovan, Fleming, Bell,[1] and MacGillivray enumerate but two species of shrew, of which one was the Water, the other a composite species compounded of the Common and Pygmy Shrews. The truth had escaped the notice of Jenyns, one of the wisest of early British mammalogists, when he wrote his *Manual*, but eventually he recognised two terrestrial species, the smaller of which he characterised as *Sorex rusticus*. No other course was possible under the circumstances, since there was at that time no available means of comparing British with continental specimens. At the same time Jenyns bestowed upon an Irish specimen the name of *Sorex hibernicus*, but his description, having been evidently based upon a comparison of an Irish Pygmy with an English Common Shrew, was founded upon insufficient basis, as he himself eventually admitted. It was left to Blasius in 1857 to express the conviction that the *S. rusticus* of Jenyns was identical with the *S. pygmæus* of Pallas, a conviction verified by the editors of Bell's second edition, who, by the kindness of the late Professor Alfred Newton, were enabled to examine Jenyns's typical specimen, presented by him to the University Museum of Zoology at Cambridge. Later researches have shown the probable identity of Pallas's *S. pygmæus* with the *S. minutus* of Linnæus, and the latter is accordingly the correct technical name for the Pygmy Shrew.

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[1] *Pachyura etrusca* (Savi).

Even of late years our knowledge of this tiny species has accumulated very slowly, and it only took its place in Bell's second edition by the medium of a single sheet, written by E. R. Alston, and issued after the completion of the rest of the work. But, only a few years previously, Alston, judging by a note which he wrote in 1865[2] on the subject, seems to have been uncertain about it. Its name was absent from reputable local faunas of so late a date as Mr H. E. Forrest's *Shropshire* (1899), George Sim's *Dee* (1903), and Mr David Bruce's *Mammalia of Caithness* (1907). It was only added to the Fauna of Staffordshire in 1885, of the Edinburgh district in

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[1] First edition.

[2] *Zoologist*, 1865, 9430.

1889, of Cheshire in 1894, and of Shropshire in 1900.[1] In fact, until the present era of systematic trapping it was universally regarded by naturalists as a much more valuable prize than it is now known to be, which is not surprising in view of the fact that in those days practically all the shrews which came to hand were provided either by the accidents of æstival mortality or by the unguided forays of the domestic cat.

In its habits, so far as our scanty knowledge goes, the Pygmy does not differ widely from the Common Shrew; it may be taken with the same traps and baits, in the same runs, and in the same localities, at all seasons and in every state of the weather. There is one, for instance, in the British Museum, which was caught by Mr R. J. Cunninghame in a Skandinavian forest, at an altitude of 1900 feet, on 15th January 1895, the trap having been placed on two feet of snow and the thermometer standing at zero. It is, if anything, of more extensive distribution than the larger species, occurring, as it does, from sea-level to the tops of our highest mountains, having been found in Scotland on a snow-patch at 2000 feet at least,[2] as well as at the summit of Ben Nevis (4400 feet), and on many desolate islands where the larger species is absent. Some writers state that, although not restricted to any particular haunts, it prefers wooded localities. Messrs G. H. Caton Haigh[3] and Lionel E. Adams[4] have nearly always found it in woods, but William Thompson particularly noted its occurrence on the loftiest of the Irish mountain-tops, "where these are clothed with verdure." It is evidently, as might be expected from its slender feet and long outer toes, an excellent climber, and one was found in a room in the upper storey of my home in Ireland, where, having ascended the curtains, it proceeded to draw so much attention to itself by its constant squeaking that it was thought to be something uncanny, and was shot. Another instance of this shrew having entered a house in county Galway was communicated to me by Mr R. F. Hibbert. But this is a common practice with shrews in the

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[1] Forrest, MS.

[2] C. H. Alston, *Ann. Scott. Nat. Hist.*, 1909, 114.

[3] MS.

[4] *Zoologist*, 1906, 439.

North, as in Norway, where, according to Professor Robert Collett, the present species attacks meat and tallow.

Blasius remarks that it is not so often seen abroad during the day as is its larger congener. But it is equally subject to a mysterious seasonal mortality, in regard to which the late Dr R. J. Burkitt wrote me that on a fine summer day he counted nine lying dead, but apparently unmauled, on his lawn at Rocklands, Waterford, in county Kilkenny; Mr J. G. Millais finds the same mortality in North Uist.

Until quite recent years there was no definite information available about the breeding habits of this shrew. The observations quoted below show, however, that the young may vary from two to eight, and that they are born at various dates between early May and September, so that probably the females produce at least two litters each summer. In the south the breeding season may be even longer, since Mr Edwin Hollis has sent me a note of a Devonshire female containing two quite small embryos on 26th February.[1] As regards other records, Mr Adams[2] found eight embryos on 5th May, while I received a female suckling young from Mr John Hunter of county Wicklow on 16th May, and another from county Galway on 6th June, in which month Mr Adams found two lots of five and six respectively, and Mr R. Patterson found eight embryos near Belfast; Professor H. Lyster Jameson found seven in Ireland on 28th June, and five well developed in county Louth on 7th July;[3] and in August Mr N. B. Kinnear found six in Orkney, and Mr Oxley Grabham five nearly ready for birth in Yorkshire.[4]

So far as I am aware, the first published description of the nursery of the Pygmy Shrew was that of Mr Millais, who met with one in North Uist in August 1899. It was "a small compact ball of dried grass interwoven and interlaced on the top with some of the fine rushes in which the nest was built. It contained five young ones about three parts grown. When held in the hand they appeared to be almost blind, and did not make any attempt to get away. In fact, I think the young of both this species and the Common Shrew remain in the nest or its close vicinity until quite full grown."

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[1] See also description of supposed nursery in Clare Island on 1st March, below, p. 120.

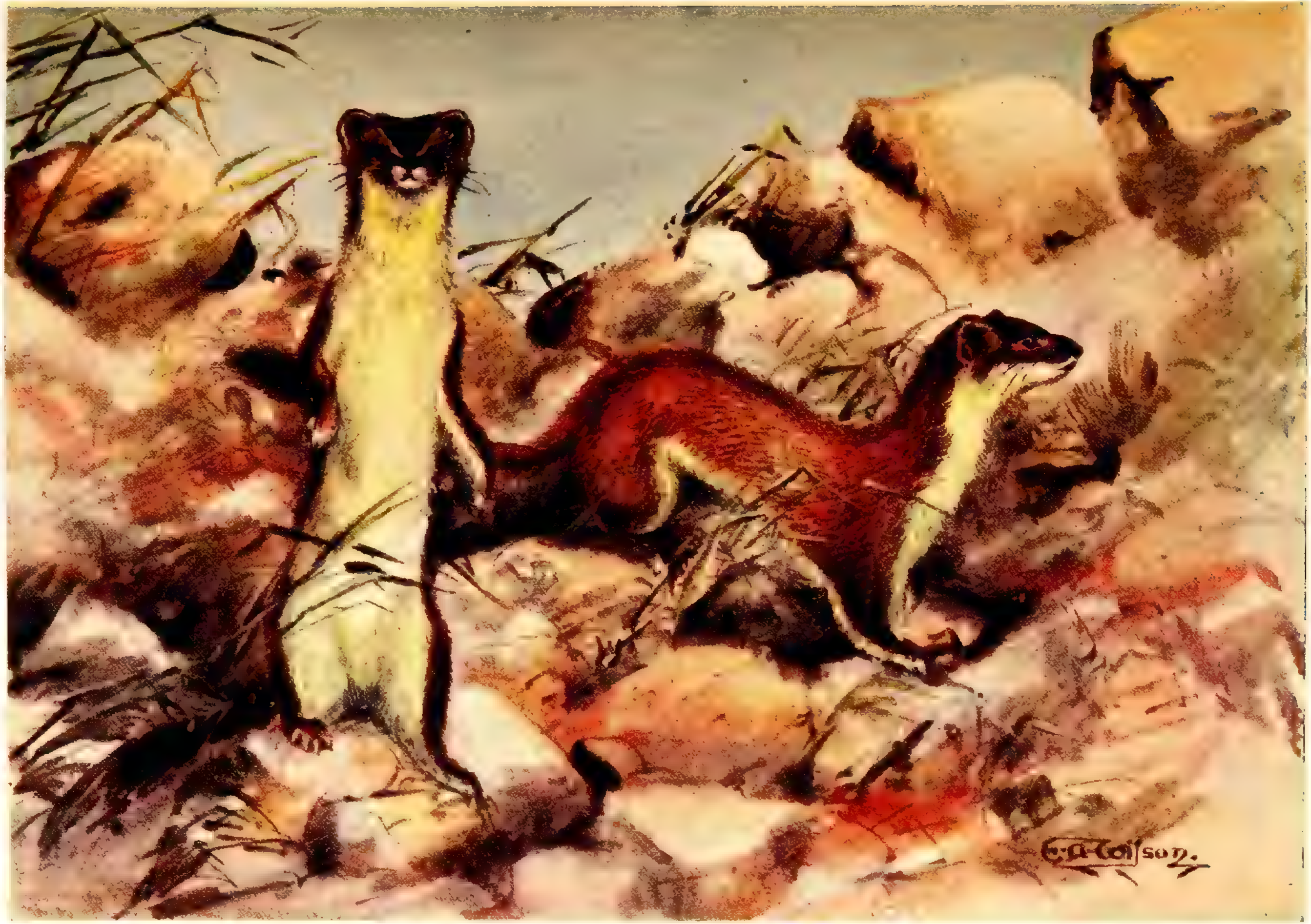
[2] *Irish Naturalist*, 1902, 176.

[3] Both in the Dublin Museum.

[4] *Zoologist*, 1895, 427.

Another nursery, found by Dr N. H. Joy, contained a similar number of young, laid on chips of wood in a cavity in a rotten stump. A nest, which was probably a breeding one, was shown to me on Clare Island, Ireland, by Mr J. J. M'Cabe, in April 1909; at that time it was deserted, having been disturbed by a man on 1st March. Happening to lift up a slab of stone lying in a grass field, he found under it, in a cavity—apparently excavated—a ball of dry cut grass, from which at least eight or nine shrews ran out. Beside the cavity, there was at the time of my inspection a short blind burrow, about an inch in diameter, in which were some wood-lice and a slug. The nest cavity was connected with the outer world by a burrow leading for a distance of a few inches to the edge of the slab. Mr Adams has sent me details of three other Irish nests. One, found under a large stone at Rathlin Island, in May 1897, was composed of moss and fine grass. The other two, constructed of dried grass only, were placed at the foot of walls at Ballycastle, county Antrim. The situation of the nests suggests that the animal makes no burrow, but utilises existing hollows.

A Pygmy Shrew was taken alive in county Wexford, from a similar nest of dried grass, in a cavity of a loose-stone wall. It showed neither fear nor ill-will, and fed freely on spiders, flies, and wood-lice, darting about after them with great activity. It seemed to make much use of its long, trunk-like nose, which was its most noticeable feature, and which continually quivered and trembled with the utmost flexibility. Worms seemed to be too large for it, and a big spider defended itself with success from all attacks. Smaller insects were seized without apparent method and munched rapidly, and certainly not less than seven or eight were consumed one after the other. For its provision at night a number of wood-lice were caught and placed in its box, and by morning all except one had been eaten, and the shrew lay dead, probably from want of water. In the midst of all its activity the little beast took constant short naps.



THE STOAT.

Regarding the care of shrews in captivity, Mr A. H. Cocks writes me that he knows of no practical way of trapping them alive, for though they will probably go into almost any form of live trap, a few minutes' detention therein is fatal, in a ratio varying with the size of the species.

"Pygmy Shrews I have never kept alive, because the transit from field to cage in a man's hand, even if it is only a few hundred yards, is either immediately fatal, or is so within the next hour or two. I frequently provide a tin with ventilation holes punched, when hay or other field work is in progress (especially when mangolds or swedes are being taken from a clamp), but no shrew is caught that day, or the next, and when at last one is captured, the tin is not forthcoming.

"With Common Shrews, which are so very much more numerous, as well as stronger, I do from time to time get one alive into a cage, but a rather large proportion die during the ensuing night. I have been careless in noting dates of arrival, but three months is probably about the extent to which one has lived.

"Insectivores, like nearly all other mammals, require to drink a good deal, and should invariably have a supply of water in captivity.

"As regards food, shrews, like moles, to which they are very similar, have an extraordinarily rapid digestion, and therefore require to eat at short intervals. A handful of worms twice a day suffices, because they disable each worm in turn, preventing it from crawling away by biting it along its whole length, and then bury it in the moss or other vegetable nesting-material provided, whence they excavate their helpless victims and devour them as appetite demands."

From the above notes, compared with those of other naturalists who have captured and kept the Common Shrew alive, it may be inferred that, although so indefatigable in pursuit of their prey, the intelligence of the shrews is not of a very high order.

It is evident that the snout is the seat of specially strong organs of sense, enabling the little animals to secure their often agile prey by scent, without the assistance of the tiny eyes.[1]

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[1] Since the above was written, Adams has specially studied the eyesight of a captive Common Shrew, and reports that it is "as blind as the mole," thus confirming Ernest Thompson Seton's poor opinion (ii., 1100) of the eyesight of American shrews.

It seems clear also that the creatures preyed upon by the Pygmy Shrew are, owing to its puny size, necessarily smaller and weaker than those attacked by the Common Shrew. But it is a bold forager, and according to Professor Collett, in Norway it sometimes searches out the nests of ground-wasps and devours the larvæ. If its appetite throughout the winter is such as the behaviour of my own captive would suggest, I am filled with wonder to know how it can obtain food in sufficient quantities.

The same idea occurring to Dr C. Hart Merriam[1] (in regard, of course, to the North American sub-species), made him conclude, although without direct evidence, that the "diet is more comprehensive than most writers suppose, and that they feed upon beechnuts and a variety of seeds,[2] and possibly roots as well." Of three which he placed together, "in less than eight hours one of these tiny beasts had attacked, overcome, and ravenously consumed two of its own species, each as large and heavy as itself."

My own experience of trapping the Pygmy Shrew is that it is unevenly distributed, as it comes to traps in a very uncertain manner. Mr Kinnear, trapping not far from where Alston in 1867 caught several, has never obtained one. Perhaps it is scattered over the country in small colonies, after the fashion of the Water Shrew, and this may account for the fact that, while in one locality it is accounted rare, in another it is abundant. There is, for instance, a dry roadside bank by a plantation in the county Wexford, overgrown with whitethorns, but bare of under-cover, where several were easily caught, while in other situations of like appearance not one could be secured. Similarly, in Germany, during six weeks spent in trapping small mammals on the outskirts of Querum Forest, Brunswick, I never met with a sign of this species until my last day, and then I was rewarded with two, the one caught on the edge of the wood, the other in a grass run in a field just outside.

A point to which Mr C. B. Moffat has drawn attention is that, although it is in Ireland free from the competition of the larger and more powerful Common Shrew, the present species has not responded by a conspicuous increase in numbers, and it is probably nowhere in that country so abundant as the Wood Mouse.[1]

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[1] *Vertebrates of the Adirondack Region*, i., 76-77.

[2] The Pygmy will come to a bait of cheese (Forrest, MS.).

It is remarkable that the Nearctic representatives of the Pygmy Shrew seem to be better known to American naturalists than the forms representing our familiar Common Shrew. Mr Thompson Seton has brought together quite a full account of the habits of the former, which are especially interesting in winter. According to Mr Nelson,[2] "the first severe weather brings them about the trading stations and native villages, and there they forage and penetrate every corner of the houses with all the persistence of the domestic Mouse. Scores of them were killed about our houses at Saint Michael every winter, and they were equally at the other stations throughout the interior. . . .

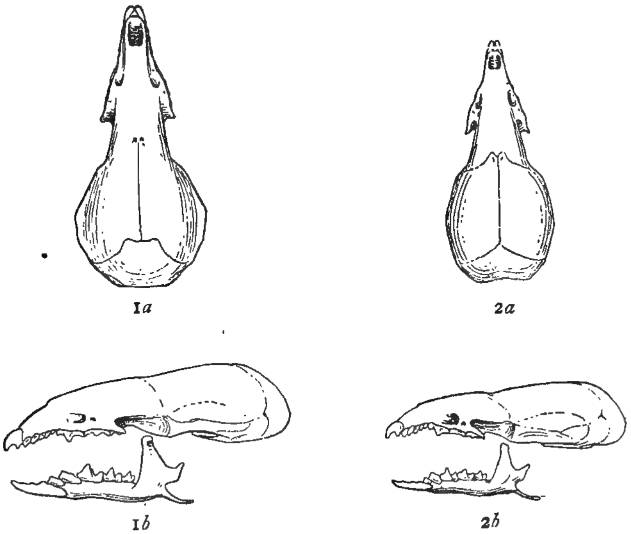

FIG. 25.—SKULLS OF (1) *Sorex araneus* and (2) *S. minutus*; (*a*) from above, (*b*) from the side.

"After snowfalls they travel from place to place by forcing a passage under the snow, and frequently keep so near the surface that a slight ridge is left to mark their passage. On the ice of the Yukon I have traced a ridge of this kind over a mile, and was repeatedly surprised to see what a direct course the shrews could make for long distances under the surface."

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[1] See *Irish Naturalist*, 1910, 125.

[2] *Natural History of Alaska*, 1887, 270-271.

In Ireland the position of the Pygmy Shrew is comparable to that of the Irish Stoat, in that it is the sole representative of its genus; while in England, on the contrary, there are two land-shrews and the Stoat and Weasel, two pairs of animals which differ considerably in size, and evidently subsist for the most part on prey corresponding to their respective strength.

When once known, the general appearance and colour of the Pygmy Shrew are easily recognised; but for those who have not previously met with it, the most useful characters are the long hairy tail, reaching a length equal to about two-thirds of that of the head and body, as against only about one-half in the Common Shrew, and the absence of a tricoloured pelt. The size of the hind feet is absolutely distinctive, and any shrew in which these reach or exceed a length of 12 mm. may be set down as of the larger species.

GENUS NEOMYS.

(*Sorex* of old writers, but not in Linnæus.)

1829. NEOMYS, Jakob Kaup, *System der Europäischen Thierwelt*, i., 117 (not *Neomys* of Bravard, 1848-1852 = *Theridomys*; not *Neomys* of Gray, 1873 = a rodent); Thomas, *Zoologist*, 1898, 100 and 102; based on *Sorex daubentonii* of Erxleben = *S. fodiens* of Schreber.

1829. LEUCORRHYNCHUS, Jakob Kaup, *op. cit.*, 118; based on *Sorex lineatus* of Geoffroy = *S. fodiens* of Schreber, and *S. leucodon* of Hermann in Zimmermann = *Crocidura leucodon.*

1829. HYDROGALE, Jakob Kaup, *op. cit.*, 123 (not *Hydrogale* of Pomel, 1848 = *Sorex fimbripes* of Bachman; not *Hydrogale* of Gray, 1865, a carnivore); based on *Sorex remifer* of Geoffroy = *S. fodiens* of Schreber.

1832. CROSSOPUS, J. Wagler, Oken's *Isis* (Jena), 275; based on *Sorex fodiens* of Schreber.

1835. HYDROSOREX (part), G. L. Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), 17 and 33, pl. i., figs. 2 and 2*b*; pl. ii., figs. 4 and 5; pl. iii., figs. 1, 7, 8, 17th June and 2nd December 1834; based on *Sorex fodiens* (description) + *S. araneus* (fig. of skull) and *S. tetragonurus* = *S. araneus tetragonurus.*

1835. AMPHISOREX, G. L. Duvernoy, *op. cit.*, 23, pl. i., fig. 1*b*; pl ii., fig. 6; pl. iii., figs. 3 and 9; based on *Sorex hermanni* of Duvernoy = *Neomys fodiens.*

1838. HYDROSOREX, G. L. Duvernoy, *L'Institut* (Paris), vi., 226, No. 112, April; and *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), Suppl., 4, pl. iii., figs. 1 and 8, 30th January 1838; based on *H. hermanni* of Duvernoy, *S. fodiens* of L. Gmelin, *S. carinatus* of Hermann, *S. daubentonii* of Erxleben, *S. remifer* of Geoffroy, and *S. lineatus* of Geoffroy, all = *S. fodiens.*

1838. PINALIA, J. E. Gray, *Proc. Zool. Soc.* (London), 1837, 126, published 14th June 1838; a MS. synonym of *Crossopus.*

1848. GALEMYS (part), A. Pomel, *Archives Sci. Phys. et Naturelles* (Geneva), 249, November; included *Brachysorex* of Duvernoy, *Crossopus* of Wagler, and *Pachyura* of de Selys; not *Galemys* of Kaup, 1829, a genus of *Talpidæ.*

1853. MYOSICTIS, A. Pomel, *Catalogue méthodique et descriptif des Vertébrés fossiles du Bassin de la Loire,* 14; based on a fossil from a late pleistocene deposit; not hitherto distinguished generically from NEOMYS.

1876. PINULIA, A. R. Wallace, *Geographical Distribution of Animals,* ii., 191; a misprint for *Pinalia.*

Synonymy:—The older naturalists included the water shrews in the genus *Sorex,* and, after its subdivision, *Crossopus* of Wagler was at first thought to be the earliest generic name applicable to them. Later researches have, however, shown that *Neomys* of Kaup has clear precedence.

The genus *Neomys* includes but one **British species**, the well-known *N. fodiens,* a characteristic inhabitant of streams and rivers, ranging across Europe and Asia at least to Tomsk, but absent from America and Africa. This species has the tail keeled (Plate VII., Fig. 3) and the feet fringed (Plate XI., Figs. 1, 2, and 3), but in central Spain and the Pyrenees; the Alps and Hungary; and near Erzerum, Turkey in Asia, there occur forms—*N. anomalus* of Cabrera; *N. milleri* of Mottaz; and *N. teres* of Miller, from the tails of which the keel is said to be absent.

Neomys makes its first known appearance in Britain in the late **pliocene** Forest-bed of Norfolk, where it is represented by the abundant remains of an extinct species called, by Hinton, *N. newtoni,* and characterised by its small size and the extreme form of the mandibular condyle. A second extinct form, to be fully described later by Hinton as *N. browni,* from the middle pleistocene brickearth of Grays, Essex, was also smaller than *N. fodiens,* and had a mandibular condyle of peculiar form.

The genus bears a strong resemblance to *Sorex,* and has a similar lateral gland and valves in the ear, although the latter are often described as peculiar. The hands and feet are also built on a similar plan, but carry swimming-fringes and smaller pads. The hand is relatively longer, so that the pads are more widely separated, especially the posterior pair (see plates). In both hand and foot the fourth, not the third, digit is the longest.

The generative organs, of both sexes, are usually described as opening within the same ring as the anus, but Adams informs me that this condition is by no means invariable. The vagina is apparently perforate at all ages (Adams). The penis is broad and provided with lateral processes. The muzzle is broader and blunter, especially at the tip, than in *Sorex*.

The stomach is globular and without pyloric elongation (Jenyns, *Ann. and Mag. Nat. Hist.*, June 1841, 267).

There are ten **mammæ**, arranged in five pairs along almost the whole ventral surface.

The **skull** is larger and the **teeth** are altogether more powerful than in *S. araneus*. The interpterygoid groove is broad and the massive naso-frontal region is evidently in correspondence with the well-developed snout. The peculiar articulation of the mandible has been described above on page 78.

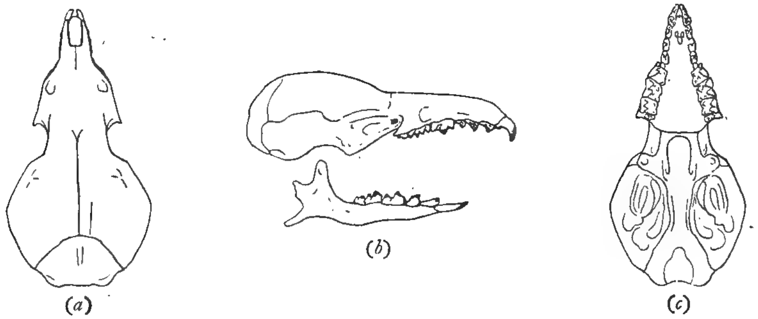

FIG. 26.—SKULL OF *Neomys fodiens*—(*a*) from above; (*b*) from the side; (*c*) from beneath. (Drawn by G. Dollman.)

The **dental formula** is—

$$i\,\frac{3-3}{2-2},\quad c\,\frac{1-1}{0-0},\quad pm\,\frac{2-2}{1-1},\quad m\,\frac{3-3}{3-3} = 30,$$

there being one unicuspid less on each side of the upper jaw than in *Sorex* (Fig. 24, No. 3, p. 90). The middle upper incisors are large and prominent, but, whereas in *Sorex* the second cusp reaches a length not much, if at all, inferior to that of the first, in *Neomys* the two are quite uneven, the second, although sharp, being so short that it alters the whole appearance of the tooth, depriving it of its forked outline. These teeth are less divaricated at their point of origin than in *Sorex;* although not always touching, they usually meet sooner, and where they approach each other a small process or fusion often joins them together. The upper unicuspids have their bases more dilated than in *Sorex;* the first and second are of about equal size and more prominent than the second cusp of the central incisors (the three are about equally prominent in *Sorex*); the third is smaller than the first and second; the fourth is minute, and, being situated somewhat inwards of the line of teeth, is partially concealed by its neighbours.

In the lower jaw the middle incisors are more produced than in *Sorex*, and their upper margin shows only one serration, an obtuse prominence situated near the base and wearing away with age. Of the two following teeth the second is the larger, and is quite distinctly forked, the posterior cusp being but little inferior to the anterior. (The teeth of the Water Shrew were well described by Jenyns in *Mag. Zool. and Bot.*, 1838, 31.)

The main cusps are coloured brown as in *Sorex*, but less markedly so, and as the animal grows older the wearing down of the colouring matter is so considerable that there may eventually remain no trace of it.

The **most nearly allied genera** have been indicated under *Sorex.* The genus is not represented in America, but the shrews of the Soricine sub-genus *Neosorex* are stated to possess almost identical habits and a very similar external appearance.

Except that they are directly fitted for an aquatic life, and their blunt snouts are not so suited for searching for insects in minute crevices, the **habits** and temperament of the water shrews do not differ strikingly from those of the preceding genus. In fact, they are not by any means restricted to the neighbourhood of water, but are capable of living, although perhaps only for limited periods, in quite dry districts, and they climb with much skill. Being larger and stronger animals than the other shrews, they frequently attack small vertebrates, and more readily submit to captivity. Their dead carcases are not encountered in anything like the numbers prevailing in the case of the land shrews, so that perhaps they live to a greater age.

THE WATER SHREW.

NEOMYS FODIENS (Schreber).
NEOMYS FODIENS BICOLOR (Shaw).

1667. MUS ARANEUS, the ERDSHREW, or FIELD MOUSE, . . . alter dorso nigro ventreq: albo, Christopher Merrett, *Pinax*, 167.

1762. MUSARAIGNE D'EAU, L. J. M. Daubenton, *Hist. de l'Acad. Roy. des Sci.* (Paris), 211, pl. 1, f. 2, 1756; described from Burgundy, France.

1771. SOREX FODIENS, Thomas Pennant, *Synopsis of Quadrupeds*, 308, sp. 236, from Pallas's unpublished plates; also, *British Zoology*, ed. 4, 1, 126, 1776 (Warrington); London issue, 1776, 110; ed. of 1812, 1, 155, pl. xi.; a *nomen nudum*, being without description and not used in binomial sense, therefore inadmissible in zoology.

1776. SOREX AQUATICUS, P. L. S. Müller, *Natursystems Supplements und Register Band*, viii., pl. ii., described from France and based on Buffon; not *Sorex aquaticus* of Linnæus, 1758, 36=*Scalops aquaticus.*

1777. SOREX FODIENS, J. C. D. von Schreber, *Die Säugthiere*, iii., 571, pl. clxi., for date see Sherborn, *Proc. Zool. Soc.* (London), 1891, 589; described from Berlin, Germany; Hermann in Zimmermann, *Specimen Zoologicæ Geographicæ*, etc., 1777, 500; also, *Geographische Geschichte des Menschen*, etc., 1780, ii., 383, sp. 314; Bingley; Fleming; Jenyns; Bell (ed. 1); MacGillivray; Clermont; Beddard.

1777. SOREX DAUBENTONII, J. C. R. Erxleben, *Systema Regni Animalis*, 124, naming Daubenton's *Musaraigne d'eau.*

1780. SOREX CARINATUS, Johannes Hermann in E. A. W. Zimmermann's *Geographische Geschichte des Menschen*, etc., i., 383, sp. 314; described from Strassburg, Germany; see Hermann, *Tabula Affinitatum Animalium*, etc., 1783, 79, sp. 5, and *Observationes Zoologicæ*, 1804, 47; Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), 17, June and December 1834, published 1835 (date from Jenyns), and *L'Institut* (Paris), vi., No. 226, 112, April 1838 (a summary of his paper read before the Nat. Hist. Soc. of Strassburg, 30th January 1838).

1791. SOREX BICOLOR, George Shaw, Shaw and Nodder's *Naturalist's Miscellany*, ii., pl. 55, and index No. 55; described from Oxford, England (date from Sherborn, *Ann. and Mag. Nat. Hist.*, April 1895, 375-376).

1792. SOREX BICAUDATUS, Robert Kerr, *Animal Kingdom*, 208: renaming Hermann's *S. carinatus* from Pennant; described from Strassburg, Germany.

1793. SOREX EREMITA, F. A. A. Meyer, *Zool. Annalen*, i., 323; described from Thuringia, Germany.

1793. SOREX FLUVIATILIS, *auct. et op. cit.*, perhaps from J. M. Bechstein, MS.; described from Thuringia, Germany.

1800. SOREX FODIENS ALBUS, J. M. Bechstein, Thomas Pennant's *Allgemeine Uebersicht der vierfüssigen Thiere*, ii., 723; described from a white variety.

1805. SOREX CILIATUS, James Sowerby, *British Miscellany*, 103, coloured plate 49; described from Norfolk, England; Bingley.

1809. FRINGED-TAILED WATER SHREW, W. Bingley, *Memoirs of British Quadrupeds*, 231, and *Synopsis*, 38, sp. 22=*S. ciliatus* of Sowerby.

1811. SOREX LINEATUS, Isidore Geoffroy, *Ann. du Mus. d'Hist. Nat.* (Paris), xvii. 181; described from Paris, France.

1811. SOREX REMIFER, Isidore Geoffroy, *op. cit.*, 182; Jenyns; Bell (ed. 1); described from Abbeville, Somme, France.

1811. SOREX HYDROPHILUS, P. S. Pallas, *Zoographia Rosso-Asiatica*, i., 130; renaming *S. fodiens* of Schreber.

1818. SOREX COLLARIS, A. G. Desmarest, *Dict. Nouv. d'Hist. Nat.*, xxii., 65, naming Geoffroy's *Musaraigne noir à collier blanc*, in *Mém. du Mus. d'Hist. Nat.* (Paris), i., 309, 1815; described from islands in the mouths of the rivers Meuse and Escaut, Belgium and Holland.

1822. SOREX MACROURUS, J. G. C. Lehmann, *Observationes Zoologicæ in faunam Hamburgensis*, i., 5; described from Sachsenwald, near Friedrichsruh, Schleswig-Holstein, Germany.

1826. SOREX AMPHIBIUS, C. L. Brehm, *Ornis* (Jena), ii., 38; described from Renthendorf, Thuringia, Germany.

1826. SOREX NATANS, C. L. Brehm, *op. cit.*, 44; described from Renthendorf, Thuringia, Germany.

1826. SOREX STAGNATILIS, C. L. Brehm, *op. cit.*, 47; described from Renthendorf, Thuringia, Germany.

1829. NEOMYS DAUBENTONII, Jakob Kaup, *System der Europäischen Thierwelt*, 117.

1829. LEUCORRHYNCHUS LINEATUS, Jakob Kaup, *op. cit.*, 118.

1829. HYDROGALE REMIFER, Jakob Kaup, *op. cit.*, 123.

1830. SOREX RIVALIS, C. L. Brehm, Oken's *Isis* (Jena), 1128; described from Renthendorf, Thuringia, Germany.

1832. SOREX MUSCULUS, J. Wagler, Oken's *Isis* (Jena), 54; described from Bavaria, Germany.

1832. SOREX PSILURUS, J. Wagler, *loc. cit.*; described from Bavaria, Germany.

1832. CROSSOPUS FODIENS, J. Wagler, *op. cit.*, 275; Blasius; Fatio; Bell (ed. 2); Alston, *Fauna of Scotland*, 1880, 10; Flower and Lydekker; Lydekker; Johnston; Winge.

1832. CROSSOPUS MUSCULUS and C. PSILURUS, J. Wagler, *loc. cit.*

1832. OARED SHREW, William Yarrell, *Proc. Zool. Soc.* (London), 109, and Loudon's *Mag. of Nat. Hist.*, v., 598, 1832; naming *S. remifer* of Geoffroy; Fleming; Bell (ed. 1).

1832-41. CROSSOPUS CILIATUS, Charles Lucien, Prince Bonaparte, *Fauna Italica*, pl. 18, fig. 7 (coloured).

1834. SOREX NIGRIPES, H. B. Melchior, *Den danske Stats og Norges Pattedyr*, 68; new name for *S. natans* of Brehm.

1835. HYDROSOREX FODIENS, G. L. Duvernoy, *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), 1834, 17 and 33, pl. 2, fig. 4; pl. 3, figs. 1 and 8, 17th June and 2nd December.

1835. AMPHISOREX HERMANNI, G. L. Duvernoy, *loc. cit.*, 23, 34, pl. 1, fig. 1*b*; pl. 2, fig. 6; pl. 3, figs. 3 and 9; described from Strassburg, Germany.

1837. AMPHISOREX CILIATUS, J. E. Gray, *Proc. Zool. Soc.* (London), 125.

1837. AMPHISOREX PENNANTI, J. E. Gray, *op. cit.*; also, *Ann. and Mag. Nat. Hist.*, 1839, 287; described from England.

1838. AMPHISOREX CONSTRICTUS, G. L. Duvernoy, *L'Institut* (Paris), vi., No. 226, 112, April, from *Mém. Soc. Mus. d'Hist. Nat.* (Strassburg), Suppl. 4, 30th January 1838.

1838. HYDROSOREX HERMANNI, H. FODIENS, H. CARINATUS, H. DAUBENTONII, H. REMIFER, H. LINEATUS, *auct. et op. cit.*

1838. AMPHISOREX LINNEANA, J. E. Gray, *Ann. Nat. Hist.*, 287, December; described from North Bothnia, Sweden.

1839. SOREX FODIENS, var. LEUCOTIS, E. de Selys-Longchamps, *Études de Micromammalogie*, 25, 142 ; described from St Gervais, at the foot of Mt. Blanc, Haute-Savoie, France.

1839. SOREX FODIENS, var. MAJOR and SOREX FODIENS, var. ALBIVENTRIS, *auct. et op. cit.*, 142 ; named, but without description.

1840. CROSSOPUS SOWERBYI, Charles Lucien, Prince Bonaparte, *Fauna Italica*, i., 29 (under *S. fodiens*), renaming *Sorex ciliatus* of Sowerby.

1853.? MYOSICTIS (CROSSOPUS) FODIENS, M. Pomel, *Catalogue méthodique et descriptif des Vertébrés fossiles du Bassin de la Loire*, 14-15.

1870. SOREX INTERMEDIUS (part), E. Cornalia, *Catalogo descrittivo dei Mammiferi osservati fino ad ora in Italia*, 27 (not seen) ; although quoted under *Sorex alpinus* by authors, is based upon a made-up specimen of *Sorex* and *Neomys;* see Sordelli, *Atti della Soc. Ital. di Sci. Nat.*, xxxviii., 362-365, 17th December 1899.

1898. NEOMYS FODIENS, Oldfield Thomas, *Zoologist*, 100 and 102 ; Miller ; Collett.

1901. NEOMYS FODIENS MINOR, G. S. Miller, junior, *Proc. Biol. Soc.* (Washington), xiv., 45, 25th April 1901 ; described from Montréjeau, Haute-Garonne, France.

1905. CROSSOPUS ou SOREX IGNOTUS, Victor Fatio, *Archives des Sci. phys. et naturelles*, 15th February, 202 ; described from Switzerland, from *Neomys fodiens* (skull) + *Sorex araneus nudus* (jaw) ; see Mottaz, *Bull. Soc. Zool.* (Geneva), i., 9, 15th November 1908, 167.

1905. NEOMYS FODIENS NAIAS, G. E. H. Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, May, 507 ; described from Hatzeg, Hunyad, Hungary.

1905. NEOMYS FODIENS CILIATUS, G. E. H. Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, 508, May ; Trouessart (1910).

1906. NEOMYS FODIENS NANUS, R. Lydekker, *Zoological Record*, 1905, 34, August 1906 ; misprint for *N. f. naias.*

The plan of the **synonymy** is the same as that of the two other shrews.

The Water Shrew owes its legion of synonyms to its puzzling variations, together with the general obscurity with which, until recent years, it has been surrounded.

The specific name *fodiens* is usually cited as of Pallas, or Pallas in Schreber, but although Pallas caused drawings of it to be made which were inspected and utilised by Pennant amongst others, they were not published in time to give the true author of the name the priority which the rules of nomenclature require. Pennant appears to have been the earliest copyist, but, since he published no description and did not follow the rules of binomial nomenclature, his *fodiens* is a mere *nomen nudum.* Schreber's *fodiens*, although there is no reason to oust it, dates from the same year as Hermann's *fodiens* and Erxleben's *daubentonii.* The latter was applied in honour of the French naturalist of that name, who independently met with and described the Water Shrew in the same year as Pallas.

The swollen synonymy dates from Hermann of Strassburg. Working with Gall's specimens, he described several forms of shrew, of which *tetragonurus* has been dealt with under *araneus; russula* and *leucodon* are each a *Crocidura*, while *carinatus* is evidently a water shrew; *constrictus* is a doubtful form, described from young in the nest and perhaps a *Crocidura.* Like Pallas, Hermann was slow to publish, and his manuscripts were copied by Zimmermann, Schreber, and others, who are sometimes cited, although wrongly, for Hermann's names, while Hermann's own work was held back until after his death.

Many years later, Duvernoy, in setting himself to explain Hermann's species, added another synonym in his own *hermanni*, and introduced confusion by including *fodiens* and *tetragonurus* in a single new genus, *Hydrosorex.* His description of *fodiens* correctly indicated a water shrew, but the skull which he figured in correspondence with it was that of a true *Sorex*, a fact which induced Jenyns to doubt the identity of British *fodiens* with that of Duvernoy, and to suggest the use of Shaw's *bicolor* (1791) for the former (*Mag. Zool. and Bot.*, 1838, 37). The truth did not, however, escape Nathusius, who, in Wiegmann's *Archiv für Naturgeschichte*, 1838, i., 19-47, reviewed the knowledge of shrews at that date, as did also de Selys-Longchamps in the year following.

Meanwhile, in 1805, Sowerby had bestowed the name of *ciliatus* upon a melanic English specimen, and Geoffroy's *remifer* (1811) was based upon a similar one from France, his *lineatus* of the same date being probably the black and white form of the same locality.

This differentiation of the Water Shrew into two forms, the one dusky, the other with white underside, met with wide acceptance amongst European naturalists; but those of Britain, except Bingley, ignored their countryman Shaw's *bicolor*, and adopted in preference Geoffroy's *remifer*, hence the presence of that term and the expression "Oared Shrew"[1] in the works of many British writers of the nineteenth century.

Gray's *pennantii* was in 1837 applied to specimens from England and France, but in 1839 he restricted it to "our English species"; his *linneana*, from North Bothnia, Sweden, and Lehmann's *macrourus*, may represent sub-species.

Shaw's *bicolor* (1791) is, without doubt, the proper technical name of the British Water Shrew, being the earliest to appear in the work of a British writer (see under Geographical Variation).

Local names:—Like the Pygmy, the present species is probably not always distinguished from the Common Shrew. The following names are said to have direct application to it:—*Blind-mouse* of the fen-men (Pennant); *famh-uisge* = "water mole" (Alston), and *lavellan* of Scotland; *otter shrew* of Cheshire (Coward and Oldham); *water mole; water-rannie; white-breasted shrew.*

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[1] "The Oared Shrew (*Crossopus ciliatus*)" appeared again, as well as the Water Shrew, in British mammals as arranged by George Abbey, *The Balance of Nature*, 1909, 5.

Distribution:—This Water Shrew ranges through arctic, boreal, and transitional Europe and Asia, from sea-level to at least 6000 feet (Blasius). It reaches the extreme north of Scotland (Bruce), and in Skandinavia (whence I have seen specimens taken at 2200 feet by Ticehurst), it is more or less numerous as far north as Finmarken (70° 45′ N. lat.), and ascends the mountains to the tree line (Collett). Thence its northern limit extends through north Russia and Siberia, southwards to central Spain, Italy to Tuscany (where it is rare, but I have seen a specimen from near Vallombrosa), Austria-Hungary (at least to Hatzeg, south Carpathians), the Balkan States, northern Caucasus and the districts of the lower Volga; and from Great Britain eastwards at least to Tomsk, the western Altais and the Jenesei. It is not found in the Himalayas, records from that region being based upon confusion with Gray's *Crossopus himalayaicus*, a *Chimarrogale.*

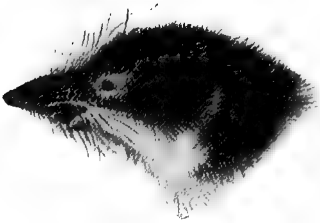
It is not represented in America (see under genus *Neomys*).

It is locally distributed all over **Great Britain**, westwards to the Pembroke coast (Howell, *Field*, 29th April 1905, 726), and Anglesey (Coward), northwards to Sutherland and Caithness (Bruce), eastwards and southwards to the sea, but doubtfully to the Isle of Wight (Bury, *Zoologist*, 1844, 780; Wadham). It is almost restricted to the mainland, being absent from Ireland, Man, the Outer Hebrides, Orkneys (Baikie and Heddle's record in *Hist. Nat. Orcadensis*, 14, being evidently an error) and Shetlands; but is not rare in Arran (Alston), and has been recorded from Kerrera (Borrer, *Ann. Scott. Nat. Hist.*, 1893, 111). I have seen an Argyle specimen from an altitude of 500 feet; Witchell and Strugnell took one in a pond at 700 feet; and on the Stafford and Cheshire border it is found at over 1000 feet (Coward and Oldham).

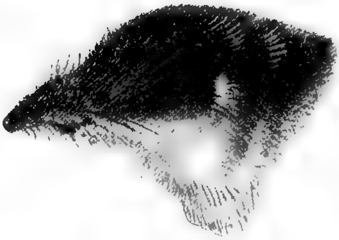
Distribution in time:—All the earlier records of *Neomys fodiens* in a fossil state in Britain (*Sorex fodiens* and *S. remifer*, Owen, *British Fossil Mammals*, 1846, 28, Fig. 14, No. 1; *Crossopus remifer*, Lydekker, *Catalogue of Fossil Mammalia*, 1885, i., 17) were based upon specimens referable to species of *Sorex.* Hinton has recently examined the fossil shrews of Britain, and finds that *N. fodiens*, or a very nearly allied form, occurs in the latest pleistocene deposits, such as those of Ightham fissures, Kent, and Dog Holes, Lancashire.

Description:—The form, general characteristics, **skull** and **teeth** of the Water Shrew are those of its genus. The under side of the tail is provided with a "keel" or double fringe of strong hairs, which extends in regular arrangement along the centre of the flat under-surface, but varies very much in development individually. The whiskers are long and numerous, reaching a length of at least 16 mm.

In the hands and feet the toes are beautifully ciliated with fringes of stiff hairs (see Plate XI.). The first and fifth digits are longer than in *Sorex araneus*, and resemble rather those of *S. minutus.* In the hand



(1)



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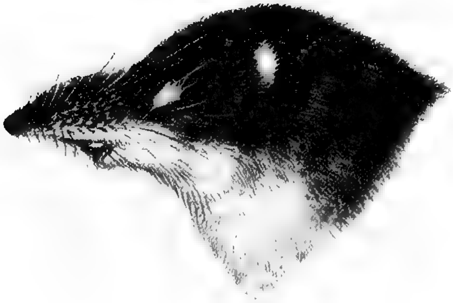

(3)

HEADS (viewed from side) OF (1) LESSER SHREW; (2) COMMON SHREW; and (3) WATER SHREW (magnified 1½ times).

the tip of the first digit reaches about to the base of the second, the fifth well beyond the base of the fourth. In the foot the tips of the first and fifth digits reach about half-way to the tips of the second and fourth respectively.

The **fur** is even more beautiful and abundant than that of the Common Shrew; it varies in length from about 4 mm. in summer to 7 in winter, and in the young possesses an iridescence lost in the adult (English). The colour of the hidden basal portions of the hairs is "blackish slate" above, paler and approaching "plumbeous" below.

The animal is in its typical form very distinctly bicoloured, the **colour** of the upper side at all seasons varying from "blackish slate," or "slate black," to deep brown of quite irregular intensity; that of the under side running from dirty white or cream to some shade of "olive-gray" or "smoke gray." The two areas are sharply divided by a distinct line of demarcation, which runs on each side from a point just behind the nostrils to the shoulder, and thence along the flanks to the wrists, ankles, and base of the tail. The tail is "hair brown" above; below, including the component hairs of the keel, whitish. The foot is also hair brown, the skin of the upper surface finely mottled in dusky and lighter colours, and the fringing hairs most typically, but not invariably, whitish. There is frequently a tuft of whitish hairs arising from a valve above the antitragus, or from the edge of the conch (Plate VI., Fig. 3). Writing in the *Zoologist* for 1893, 302-303, Stott described the eye of a fresh specimen as "blue, and small."

. The **moults** appear to be effected in a similar way to those of *Sorex*, and Adams has sent me several specimens clearly undergoing a change of their coat in September, so that there is certainly an autumn moult. The keel and swimming-fringes are changed with the rest of the hairs in summer or autumn, at which time, accordingly, errors in identification are liable to occur. The moults are probably not so irregular as in the short-lived members of the genus *Sorex*, in which Adams believes that no individual survives to effect a second autumnal moult, nor changes its pelt more than twice during its life, so that the dependence of these two changes upon the age of the individual would account for much irregularity. The *young Neomys* is at first without a keel, which makes its first appearance at the base of the tail.

Individual variation is frequent, tending largely to melanism, in the extreme case of which there is no line of demarcation and the whole under side may be dusky or "hair brown." Many specimens are strongly washed with yellowish or ferruginous tints beneath; in others there is a dusky band across the throat or a thick line of the same colour in the mid-ventral region. There may be indications of a brown flank-band between the blackish and whitish hues of upper and under sides (Cocks). Adams finds that in melanic specimens the keel and foot fringe are more prominent than in the bicoloured type.

DIMENSIONS IN MILLIMETRES :—

	Head and body.	Tail without terminal hairs.	Hind foot without claws.	Ears; greatest length.	Weight in grammes.
SPECIMENS IN BRITISH MUSEUM OF NATURAL HISTORY.					
Number of items of both sexes	11	11	11	5	..
Maximum	90	60	18	9	..
Average	85	53	17	8·5	..
Minimum	75	48	16·5	8	..
SPECIMENS MEASURED BY L. E. ADAMS.					
MALES.					
Reigate, Surrey :—					
1. 27th June 1911	85	51	17	..	..
2. 19th August 1911	86	53	18	8	14
FEMALES.					
Reigate, Surrey :—					
1. 5th February 1908	78	52	18·5	..	9 nearly
2. 1st September 1909	75	58	17	..	..
3. 1st September 1909	83	52	16	..	..
4. 1st October 1909	90	63	17	..	..
5. 7th December 1909	83	54	16·5	..	..
6. 3rd November 1910	82	59	18	..	..
7. 18th June 1911 (contained 7 embryos)	85	55	18	7	11
8. 2nd July 1911	80	53	16	8	13
9. 17th August 1911	78	55	18	8	11
Approximate average of 9 females	81·5	55·5	17·2	7·6	11
Bishop's Stortford, Herts :—					
1. 22nd September 1911	85	55	17	8	..
2. 26th September 1911	84	53	17	8	13
3. 29th September 1911	84	53	18	8·5	13
4. 4th October 1911	78	61	18	8	12
Approximate average of 15 of both sexes	82·5	55	17·3	8 (nearly)	12
IMMATURE SPECIMENS MEASURED BY L. E. ADAMS.					
Reigate, Surrey :—					
1. Female, 14th October 1909	73	55	16	..	..
2. 20th August 1911	80	55	18	8	10·5
3. 24th August 1911	80	53	17	8	10·5
4. Female, 20th September 1911	75	55	18	10	..
5. Hambleden, Buckinghamshire, caught on a road far from water; keel beginning to show at base of tail (forwarded by A. H. Cocks, 19th August 1911)	60	40	15	5	..

Exceptional variation is somewhat difficult to recognise in an animal so naturally variable. Albinism is certainly rare, but a specimen thus affected is stated to have been included in the collection of Eyton (see *Mag. Zool. and Bot.*, 1838, 540), and Bechstein's variety *albus* was based upon a snow-white example. Witchell and Strugnell mention "a pregnant albino female," which had been killed in the Thames and Severn Canal, near Brimscombe, Gloucestershire.

Geographical variation is in the Water Shrew much obscured by the prevalence of melanism. There is as yet no evidence that this melanism has in Britain any recognisable distribution according to locality, and I have not attempted to trace it here, though the subject is worthy of the attention of local naturalists. On the other hand, I have been able to show (*Ann. and Mag. Nat. Hist.*, 1905, 508) that British specimens are on the average duskier than those of the neighbouring continental regions, so that the British form deserves sub-specific recognition under Shaw's name, *bicolor*. At the other end of the scale is the beautiful southern Carpathian form which I named *naias*, but which later revisers have united with the true *fodiens;* in this the contrast between upper and under sides is stronger than in any other known form, yet melanic specimens nevertheless occur, as they probably do everywhere throughout the range of the species. No other sub-species are known.

Proportionate lengths:—Tail (without end hairs) about ·62, hind foot about ·2, and ear about ·1, of head and body.

Skull:—Greatest length, 20 to 22; basal length in middle line, 18; palatal length in middle line, 10; length of upper tooth series, 9 to 11; ditto lower, 8 to 10; greatest breadth, 10 to 11; breadth at constriction, 4·5 to 5.

The **weight**, as given in the above tables, seems to be somewhat small, considering the size of the animal. Kinnear, however, sends me the figures (in grammes) for two females as 10·32 and 10·39, but another weighed by Laidlaw reached 16·4 (Eagle Clarke).

Distinguishing characters:—As compared with the Common and Pygmy Shrews, the Water Shrew is a bigger animal, with a blunter muzzle, a large tail reaching about ·6 of the head-and-body length, the feet and tail beautifully "feathered" for swimming, and the colours, except where melanism occurs, strongly contrasted dusky and cream. The cranial and dental characters are absolutely distinctive.

The habits of this beautiful little creature are clearly indicated by the peculiarities of its structure. It possesses somewhat the same conformation as the two species already described, combining a thick silky coat and gracile body with a much thicker snout. The addition of stiff cilia to the sides of the toes, together with the fringe of hairs on the under surface of the tail, show that in its ordinary pursuits it requires the use of oars and rudder, and that, while, like the other British species of the family, its food usually consists of small invertebrates, it is in the water that this food is for the most part obtained. The observations of a number of intelligent naturalists have afforded many curious details as to its mode of life, and we now know that it is not less interesting in its habits than elegant and pleasing in its form and movements.

The Water Shrew was evidently known to Merrett, but appears to have been unnoticed by naturalists for about a century afterwards, being absent from the earlier editions of Pennant. It was eventually rediscovered almost simultaneously by Daubenton, who wrote a description of it in 1756, in France, and by Pallas at Berlin.[1] The latter naturalist supplied Pennant with some unpublished prints of it in 1765, and Pennant himself met with it at Revesby Abbey, the Lincolnshire seat of Sir John Banks, in 1768.[2] Thereafter it became familiar to several of our early naturalists, including Patrick Neill, its first observer for Scotland, in 1808,[3] George Montagu for Devonshire,[4] Fleming,[5] and Sowerby. These writers knew it well enough to fully appreciate its vagaries of colour. Montagu, for instance, described a specimen with the throat and breast ferruginous, while Fleming commented on the dark markings of the under side and upon the occurrence of an individual having a deep chestnut throat-band. Sowerby went a step farther and figured under the name of *S. ciliatus* a melanic specimen from Norfolk, which Jenyns with his usual perspicacity perceived to be specifically identical with ordinary *S. fodiens* of the same district. Nevertheless he admitted to the British list another supposed species, the Oared Shrew, *S. remifer* of Isidore Geoffroy, with the result that in the works of many British writers, such as Bingley, Bell (first edition), MacGillivray, and others, England was for long reputed to possess two species of Water Shrew, the Common or *S. fodiens* and the Oared, being either Sowerby's or Geoffroy's species. Other writers, such as Donovan and Fleming, never divided the species, and the matter remained for long unsettled. The Oared Shrew was finally removed from the British list by R. F. Tomes, who in Bell's second edition showed that both the names *ciliatus* and *remifer* were applied to dark forms of *S. fodiens*. And here the matter rested until I pointed out that British specimens are on the average duskier than those from the Continent, and therefore represent a sub-species to which Sowerby's name is applicable.

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[1] In his *Zoographia Rosso-Asiatica* (1811, i., 130), Pallas states that he first observed it "jam puer Ao. 1756 circa patriam urbem Berolinum."

[2] So far as I am aware, Pennant nowhere explicitly states that he personally rediscovered the Water Shrew. But he was at Revesby Abbey in 1768, where, according to his own *Literary Life* (1793), he made many discoveries, and he states in his *Synopsis of Quadrupeds*, 308 (Chester, 1771), that the species was lost in England until "May 1768, when it was discovered in the fens near Revesby Abbey, Lincolnshire." The evidence, although circumstantial only, is, therefore, conclusive, even without Gilbert White's statement in his xxvith letter, dated 8th December 1769:—"De Buffon, I know, has described the water shrew-mouse: but still I am pleased to find you have discovered it in Lincolnshire, . . ."

[3] In the 1808 edition of Allan Ramsay's *Gentle Shepherd*, i., 269, as pointed out by W. Evans correcting E. R. Alston.

[4] *Linnean Transactions*, vii., 276, 1804.

[5] *Wernerian Society's Memoirs*, ii., 238, 1812.

There is, perhaps, no British mammal whose manners so easily lend themselves to observation as the Water Shrew. Either because it pursues its business with a complete intentness and abstraction from other affairs, or because, as is more likely, since its eyes are very inconspicuous and lie almost buried in its fur, the sphere of its vision is very limited, it may be approached somewhat easily and by a quiet observer is not easily put to flight. Its ordinary occupations and appearance have therefore been frequently described. It was fairly well figured by Bingley and by Donovan, particularly by the former; and its mode of life was not inaccurately epitomised in their respective works, but J. F. M. Dovaston[1] is usually credited with having written the first detailed description of its habits. During the spring of 1825, Dovaston observed it repeatedly. Its manner was to glide "from the bank, under water, and bury itself in the mass of leaves at the bottom. . . . It very shortly returned, and entered the bank, occasionally putting its long sharp nose out of the water, and paddling close to the edge. This it repeated at very frequent intervals, from place to place, seldom going more than two yards from the side, and always returning in about half a minute. . . . Sometimes it would run a little on the surface, and sometimes timidly and hastily come ashore, but with the greatest caution, and instantly plunge in again. . . . When under water he looks grey, on account of the pearly cluster of minute air-bubbles that adhere to his fur, and bespangle him all over."

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[1] Loudon's *Mag. Nat. Hist.*, ii., 219, 1829.

Although Dovaston's essay undoubtedly deserves the commendation with which it has been received, J. S. Knapp's treatment of the same subject, published at about the same date as Dovaston's, is also worthy of praise.[1] Since that date, many naturalists have repeated or amplified the story, and the work of MacGillivray, J. G. Wood, Mr W. Hodgson,[2] and Mr W. Evans[3] are particularly to be commended. The two latter naturalists have especially noticed the buoyancy of water shrews, and their playfulness both in the water and on land. "When the sun shone out brightly," wrote Mr Hodgson, "their glossy submerged coats glistened like frosted silver. . . . Their watery gambols strikingly reminded the spectator of those of a brood of ducklings at play." Quite recently Mr J. G. Millais has waxed eloquent over this wonderful activity, and has figured one in the act of leaping clear of the water in a surprising, fish-like manner. He regards "the habit of making big bounds" as especially characteristic of the animal, which, indeed, not unfrequently indulges in them when surprised ashore, setting off "towards the river or pond with immense leaps through the grass, which if the animal were of the size of the spring-buck would be among the marvels of animal progression."

The Water Shrew is not by any means a rare animal, but it would appear to be of local distribution. Since the introduction of improved methods of trapping small mammals it often falls a victim, taking freely almost any bait if placed in localities where it occurs. Sometimes it may be caught in an unbaited cyclone trap placed on the bottom of a stream on the chance of its trying to pass through it.

It swims principally by the alternate action of both pairs of feet or by flexions of the whole body, which produce an unequal or wriggling motion. The head is slightly raised above the surface, says Mr Douglas English,[4] and three-quarters of the body are out of the water. The most remarkable feature of its appearance when *in* the water, and on this point all observers are agreed, is a curious flattening of the body, the sides being expanded and the tail, of course, extended backwards. It swims with great velocity, and is equally at home beneath or on the surface, but, according to Mr English, dislikes long immersions, which sodden the hair on its head and back. Like the dipper amongst birds it possesses the power of walking, or even of rapidly running upon the bottom of a stream,[1] and its activity is so surprising as to give the impression that it can walk on the surface also. Again, like some species of sea-birds, it simply runs in and out of water, as Mr E. T. Daubeny has remarked,[2] as if air and water were both alike to it, and it were equally at home in either element, but it can dive well enough if disturbed, dropping in with a little splash.[3] It is at all times a very beautiful and pleasing object. When submerged, innumerable bubbles, resting on its deep brown coat, silver it to a blue-grey tint; then as it leaves the water its fur is seen to be perfectly dry, having repelled the liquid as completely as the feathers of a water-fowl.

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[1] *Journal of a Naturalist*, ed. 2, 143, etc., 1829.

[2] *Trans. Cumberland and Westmorland Assoc.*, xi., 38-39, 1886.

[3] See also V. Walmesley, *Zoologist*, 1844, 428-429; and C. E. Stott, *Journ. cit.*, 1893, 302.

[4] *Some Smaller British Mammals*, undated, 73.

Although it obtains most of its food in streams or ponds, the Water Shrew is in no way dependent for its existence upon water. In fact, it has been so often found at such distances from situations apparently most congenial, as to suggest that it is at least equally at home in woods and pastures. It is its habit to haunt the ponds or streams which it affects in pairs or little colonies, and it is possible that on the exhaustion of the food-supply in these, it resorts to dry land, there to wander until it finds some new aquatic locality untenanted. In some cases its presence in a dry locality is probably due to its following up some old, and now hardly perceptible, water-course. This is the case in the dry farm occupied by Mr A. H. Cocks, where there is a water-course which flows during a very few weeks at irregular intervals of a few years down the valley to the Thames.[4] The water shrews discover the first moistening of the bed, before it is noticeable to human eyes, and follow it up, gradually dispersing to right and left into the perfectly dry fields.

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[1] See H. Laver's *Essex;* also W. Prior, *Naturalist*, 1899, 240.

[2] *Nature Notes*, 1902, 227. [3] T. A. Coward, MS. [4] A distance of four miles.

The Water Shrew has been observed hunting amongst dead leaves in plantations,[1] and grubbing in the droppings of horses on a public road,[2] as well as in hay- or corn-fields.[3] It has been turned out from a snug retreat amongst the roots of an old hedge,[4] has been found dead on top of a ridge of dry hills, and has been taken in the pantry of a house, in a greenhouse,[5] and in a box full of straw in a dry cellar.[6] In one instance reported by Mr C. H. B. Grant, one was trapped on ground "like a rock" at a distance of about three miles from any water in the intensely dry heat of August 1899.[7] It may even breed at a distance from water, since Mr F. Coburn[8] received a nursing female, which had been caught by haymakers near Birmingham on 27th June, in a meadow far from any river or stream.

Like the other shrews, this species is a kind of omnivorous carnivore, devouring, apparently without fear or favour, all living things of a size and strength inferior to itself. Mr Millais once observed one burrowing like a mole for worms by a streamside, but there can be no doubt that its more ordinary food is found amongst the smaller inhabitants—the crustaceans, molluscs and insects—of the brook or pond. These it hunts with great assiduity, turning over pebbles and poking its nose under larger stones or amongst dead leaves and mud for its prey, which when caught are usually conveyed to the bank or even to the burrow to be devoured. The feeding-place may be indicated by a heap of rejectamenta, as found by Mr W. Jeffery, junior,[9] who observed one making a meal of caddis-

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[1] W. Webster, junior, *Zoologist*, 1848, 2009; and H. B. Tristram, *Journ. cit.*, 1853, 3905.

[2] Sir O. Mosley, *Zoologist*, 1850, 2697.

[3] G. Wolley, *Journ. cit.*, 1848, 2289.

[4] J. J. Briggs, *Zoologist*, 1848, 2280-2281.

[5] Forrest, MS.; see also James Hardy, *Proc. Berwickshire Nat. Club*, viii., 527, 1879.

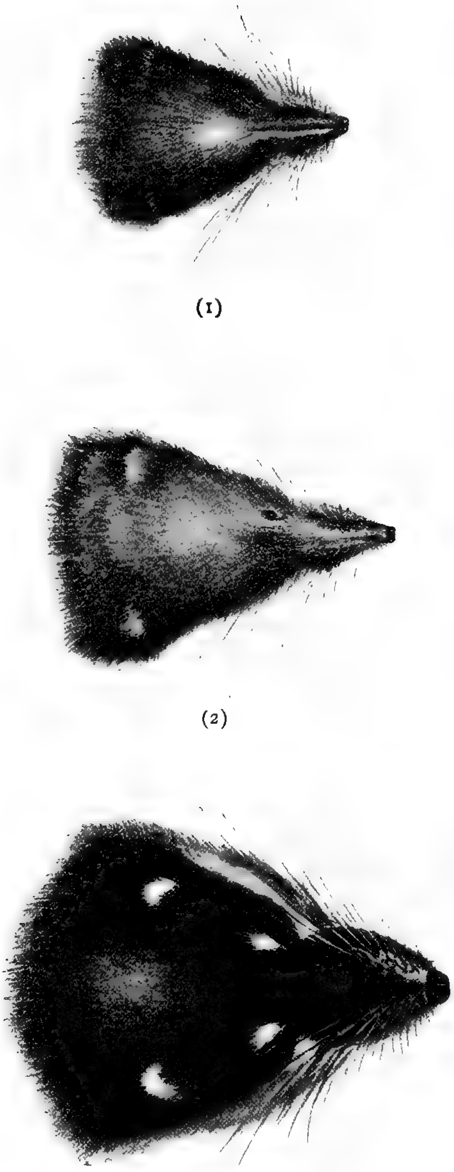
[6] Eliza Brightwen, *Wild Nature won by Kindness*, ed. 7, 121, etc., 1896.

[7] *Zoologist*, 1900, 141; see also O. Grabham, *Journ. cit.*, 1900, 186; Jenyns, MacGillivray, Evans, Service, etc.

[8] *Journ. cit.*, 1891, 185. Cocks's captive mentioned below on p. 145, produced young immediately after having been caught in a very dry field of clover.

[9] *Zoologist*, 1874, 3829; also *Journ. cit.*, 1868, 1254.

PLATE X.



(1)

(2)

(3)

HEADS (viewed from above) OF (1) LESSER SHREW; (2) COMMON SHREW; and (3) WATER SHREW (magnified 1½ times).

worms, the empty cases of which were deposited at a single place on the bank: and Mr Coward has also sent me an instance of the same kind of deposit on an old moorhen's nest.

There is ample evidence to show that the Water Shrew will eat, or at least attack, both frogs and fish, together with their spawn[1] and fry. Frogs even of large size are seized by the nose or leg[2] and dragged off, with much shaking and outcry, to the burrow. Attacks on fish have been but rarely witnessed, but the complaints of fish-farmers are very detailed[3] and are not contrary to the observations of Mr English and of the principal foreign zoologists such as Professor Robert Collett for Norway, who write of the piscivorous habits of the Water Shrew as proved beyond doubt. Of British instances may be cited Mr T. J. Bold's statement that he shot a water shrew and a fish, which he discovered "apparently rolling over and over in the water, and doing battle with all their energy."[4] A correspondent of the late John Cordeaux's[5] was also so fortunate as to witness the struggles of a water shrew and a small fish, which it seized "with all the pluck and ferocity of an otter poaching in a salmon-stream." Again, Mr E. G. B. Meade-Waldo informed Mr Millais that he has frequently seen these shrews chasing trout "up to a fair size," and there is among other evidence, that of Messrs J. A. Harvie-Brown and T. E. Buckley.[6] Monsieur H. Gadeau de Kerville has, however, pushed the accusation further home, quoting Brehm as having observed one perched on the head of a carp, where it hung on by its claws, and declaring that it evinces a particular desire for the brain of fish, in order to satisfy which it does not hesitate to attack large carp, clawing at their heads, tearing out and eating their eyes, piercing the cranium and devouring its contents.

[1] A. Trevor-Battye in Lydekker; see also, *Field*, 3rd July 1909, 44; and Hy. S. (the late Henry Scherren), *Field*, 10th July 1909, 94, where much evidence, both for England and the Continent, is collected.

[2] C. R. Bree, *Zoologist*, 1853, 4047; W. Jeffery, junior, *Journ. cit.*, 1868, 1254.

[3] A. Severn, Bibury Fishery, near Fairford, Gloucester, *Field*, 18th November, 1905, 907; Donald Walker, Welham Park Fish Hatchery, Malton, Yorkshire, *Journ. cit.*, 25th November 1905, 943.

[4] *Trans. Tyneside Nat. Field Club*, v., 155, 1862.

[5] *Zoologist*, 1881, 207-208.

[6] *Vertebrate Fauna of Sutherland, Caithness, and West Cromarty*, 1887, 72-73.

The wide range of the Water Shrew's appetite is nowhere so well shown as when traps are set for it, for, although the most successful bait is probably raw meat in one form or another, and especially pieces of liver, it will eat any ordinary mouse-attracting substance such as cheese.[1] In addition, it does not despise carrion nor the bodies of other small mammals. Several instances of this kind are related in Bell's second edition. In one case a shrew was discovered in the interior of the carcase—half-dried and decomposed—of a barn-door fowl. Another shrew was found perched on the body of a full-grown trapped rat,[2] the tough skin of which it was attempting to pierce. Despite its projecting snout and comparatively weak teeth, it had succeeded in making a small hole through the rodent's skin; and it was most energetically employed on the enlargement of this by means both of teeth and claws. So ferocious were its actions that it might very properly be described as fighting the rat, and so intent was it upon its work that it allowed itself to be captured without resistance. Continental naturalists[3] complete the dietary by the addition of young birds and animals, and there is not the slightest doubt that these may be occasionally attacked by it.

Like the Common Shrew, the present species is, at least in summer, the reverse of silent, and its cry, a shrill, chattering shriek, sometimes challenges attention. Dovaston was, however, perhaps a little too picturesque when he expressed it as a "very short, shrill, feeble sibilation, not unlike that of the grasshopper-lark, . . . but nothing near so loud or long-continued." It is probably best described by the epithet "cricket-like," and is difficult to distinguish from the voice of other shrews. In winter, according to Mr Robert Drane,[4] the cry is rarely heard.

The residence of this animal is usually a burrow, sometimes an elaborate system of galleries with one or more of the entrances opening under water. It thus possesses a retreat whether pursued from the land or from the water, but to what extent it digs it for itself is uncertain.[5] Probably, like other mammals not specialised for digging, it utilises ready-made burrows as much as it possibly can. But this does not mean that it cannot also dig for itself, and one which Mr Cocks kept in captivity for some months finally escaped by grubbing away the somewhat decayed edges of two boards in a very vigorous manner. Monsieur de Kerville describes the burrow as being provided with three entrances, one submerged, a second at the surface of the water, and the third, sometimes multiple, opening to the land and away from the stream; but such a plan is certainly not invariable, for I have caught a Water Shrew by damming up a small stream and flooding it out of its abode. Occasionally, according to Blasius, it is said to make use of the galleries of the Mole.

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[1] Evans; Forrest, etc.

[2] See also R. F. Tomes, *Worcestershire*, 175.

[3] *E.g.*, Blasius; and de Kerville.

[4] MS. per T. W. Proger.

[5] Collett states that it *does* dig.

In the deep recesses of the burrow may be found, according to Mr Millais, "a compact ball of grass with a few oak leaves, very similar to the nest of the Common Shrew, only larger."[1] Two such were found contiguously by Mr C. E. Wright[2] under a wild duck's nest in an old pollard willow. They were composed of shreds of wood, small willow roots, and a few pieces of fine grass.

Like the other shrews, this species is by no means entirely nocturnal, and it is frequently to be observed abroad by day. That it also moves about by night is shown by the occurrence of its skull in the "pellets" of owls, and these birds have been seen hunting it.

It is also as active in winter as in summer, and Mr G. H. Caton Haigh has often seen it swimming under the ice beneath his feet while skating, thus confirming similar statements by Blasius for Germany and Pallas for Siberia. A charming account of its movements in a half-frozen burn may be read in the *Lays of the Deer Forest*, by John Sobieski and C. E. Stuart.[3] Occasionally, however, as Jonathan Couch noticed in 1855,[4] the shrews are driven from their ordinary haunts by the ice; but the plump condition of those which he found showed that they had not owed their death to starvation. It is probable, according to Mr Millais, that heavy floods are more disturbing to them than any atmospheric changes such as frost or drought.

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[1] A little chamber lined with moss (Collett).

[2] Per L. E. Adams, MS.

[3] Vol. ii., 311-313.

[4] *Zoologist*, 1855, 4702.

Although there is as yet no evidence that, as suggested by Mr Adams's observations on the Common and Pygmy Shrews, this species is also an "annual," it is subject to the usual mortality of its family, as noticed by Knapp,[1] by Couch,[2] and, over one hundred years ago, by Shaw. But the number of deaths seems to be much less than in the two other species; and Mr Drane[3] remarks that in Norfolk he daily found dead ones on roads and paths in winter, but only in that season. It is so irascible and pugnacious that it sometimes falls a victim to its love of fighting. In Scotland one of Buckley's[4] correspondents found two in a new cistern, from which they were unable to escape; one was sitting upon a stone busily engaged in devouring the remains of its companion in misfortune. Mr Harvie-Brown sends me a somewhat similar tale of cannibalism, and Cordeaux[5] once found a pair of fully grown males in June sitting face to face, dead, but posed in a life-like attitude. Both were in good condition and exhibited no trace whatever of ill-usage, except slight stains of blood on their chests. In the island of Kerrera, William Borrer[6] also met with the bodies of two males in equally good condition. They too had probably fallen in mortal combat, although they were separated by a distance of a few yards.

When intent upon its food,[7] or perhaps, only if unwell, this shrew may sometimes be approached and taken alive, as already described above, in the case of one found grubbing amongst dung upon a road by Sir O. Mosley.[8] It is not, however, at all tractable, and, when seized, bites savagely, its sharp teeth being powerful enough to pierce a thick glove.[9] Mr Rope has noticed[10] one of its most astonishing accomplishments, namely, its skill in climbing; one which he kept in a cage for a few hours not only ascended easily the upright wires of its prison, but even made its way along the top, clinging back downwards to the wires, an unexpected exhibition of agility in such a usually aquatic animal. This power of climbing had been previously observed by an anonymous, but evidently, as regards this point, accurate writer, who stated[1] that he had kept a pair, male and female, in captivity with some success, feeding them on raw meat and small fish, which latter they held with their forepaws, like an otter. Mr English, whose remarks have been quoted above, and Mr Cocks have kept various individual water shrews in captivity for long periods. They appeared to have some notion of making a foodstore, since Mr English observed that after clearing their tank of its living contents, as they always did in the course of a night, there were always to be found in the morning seven or eight small fishes piled neatly in some high, dry corner; and, as already mentioned, Mr Cocks found that worms were disabled and stored for future use.

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[1] *Op. cit. supra.*

[2] *Zoologist*, 1855, 4702.

[3] Per T. W. Proger, MS.

[4] *Ann. Scott. Nat. Hist.*, 1892, 157.

[5] *Zoologist*, 1866, 327; see also Grabham, *Journ. cit.*, 1900, 186.

[6] *Ann. Scott. Nat. Hist.*, 1893, 111-112.

[7] According to Collett it sees well at a distance.

[8] *Zoologist*, 1850, 2697.

[9] J. J. Briggs, *Zoologist*, 1848, 2280-2281.

[10] *Journ. cit.*, 1900, 477.

Mrs Brightwen fed two upon the heads of fowls. She remarks that "there is hardly any animal in England so fierce and combative."[2] If the attention of one were attracted by a feather, "he always came out of his bed and sprang upon the feather like a little tiger, dragging it about and holding on with the grip of a bull-dog, so that one could lift him off the ground and keep him swinging a minute in the air."

Mr Cocks, who writes[3] me that water shrews, being much the largest and strongest of the three British species, are more easily transferred from a wild life to a cage, has published a lively account of one which lived in his care for a day over eight months.[4] Having been caught on 8th August, she gave birth "to a litter of four or five young during that night; they were blind and naked, and hardly larger than common house-flies, not nearly so large as bluebottles. She had had no time to prepare a nest, and after taking every care of them for two whole days, she ate them during the third night.

"Up to the time of writing, she has thriven on a 'diet of worms,' occasionally varied by a beetle, grub, moth, etc., and captured a fly which incautiously came of its own accord within reach. A cockchafer was evidently considered a great (in both senses) prize, and she attacked it standing on three legs, one or other forepaw in turn being held raised, ready for action perhaps in case the victim resented being eaten piecemeal. It is amusing to watch her with a large worm when the latter is lively; the encounter then becomes heroic. She does not care for snails so long as the worms continue in such plenty. Of these I reckon that she eats quite once and a half her own bulk daily, and fully twice her own weight. The amount which passes from her, consisting chiefly of the earth contained in the worms, is on a correspondingly surprising scale. When excited she utters a rather shrill chatter, which is always, so far as I have noticed, sustained for half a minute or so, and never limited to a single note. As may be expected from the elongated, delicate snout, the shrews hunt their prey by scent. This specimen raises its long flexible nose nearly straight up, and bends it on itself rapidly from side to side, and very quickly discovers the whereabouts of a worm. When yawning, the flexible nose is turned considerably up—nearly to a right angle with the gape, and the upper incisor teeth then show as of surprising length."

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[1] *Field*, 3rd October 1863, 345.

[2] *Op. cit.*, 124.

[3] Amplifying his account in *Vic. Co. Hist.*, *Buckinghamshire.*

[4] Another lived for several months.

The female Water Shrew, which is about the same size as the male, constructs a nursery for her young in a cavity filled with moss or herbs and placed at the end of a burrow, which, like the ordinary non-breeding tunnels, may have more than one opening, either above or below the surface of the water. But probably no one plan prevails to the exclusion of others, and Mr Millais, who took the trouble to have the galleries belonging to a colony dug out, found them to constitute a very elaborate system.

The young, which usually number from five to eight, make their appearance after a period of gestation, computed by Blasius at about three weeks. They grow so rapidly that by the time they reach the age of five or six weeks they are able to cater for themselves and to leave their mother.[1] It is probable that more than one litter sees the light each summer, the first in May or June and the last in September, on the 5th of which month Mr Rope[2] caught a large pregnant female.

[1] Blasius.

[2] *Zoologist*, 1900, 477.

Mr Millais had another on the 15th of the same month, and Mr W. Eagle Clarke on the same date obtained one in the nursing condition from Peeblesshire, while Blasius states that he twice saw the young on foot in late summer. Mr Adams caught a nursing female on 2nd October 1909.[1]

The playfulness of young water shrews has often come under the notice of naturalists, and has been most graphically described by Mr Hodgson,[2] who watched a family of seven, being five young and two parents. "At the termination of a drain, where it emptied into an open water-course, was the entrance to their burrow. The field was in grass at the time and depastured with cattle. In a semicircle round their hole were a number of grass-covered runs, artistically arranged with the view apparently of forming a first-class recreation ground. A number of paths, wide enough only to accommodate a single shrew, radiated from the burrow as a centre, each extending about 7 or 8 feet in length. These were crossed by parallel semicircular tracks about a foot apart, the entire ground plan giving much the idea of a geometric spider's web cut in half. Along these tracks, lengthwise and crosswise indiscriminately, the youngsters chased each other with almost lightning speed. Should any two of their number chance to 'foreset' each other, there was a squabble, and much shrill recrimination resulted. When tired with racing long, they would suddenly scuttle into the burrow, only to return in a few minutes and renew their frantic exertions."

It is not known when the little family disperses or how long the young remain with their parents. It seems clear that the parents do not separate before or after the birth of their offspring, and it is very probable that the family party, as in the case of some other small mammals, may remain together for some little time, perhaps even for months. Probably, also, the breeding season brings these shrews together in companies, which would account for the party of nine or ten encountered by the late Canon H. B. Tristram[3] on 6th May, as well as for a concourse of twenty or thirty observed in Yorkshire by Mr W. B. Arundel on the 10th of the same month.[4]

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[1] *In lit.*

[2] *Trans. Cumberland and Westmorland Assoc.*, xi., 38-39, 1886.

[3] *Zoologist*, 1853, 3905.

[4] *Ibid.*, 1908, 189.

Apart from its colour, size, and the important cranial and dental characters, the greater size of the hind foot, measuring 16 to 18 as against 12 to 14 mm. in the Common Shrew, is probably the best absolute criterion of this species.

[Remains of a Desman from the late pliocene Forest-bed of Norfolk were first described by Owen, in 1846, under the name of *Palæospalax magnus.* Of late years they have been referred to the living "*Myogale*" = *Desmana moschata* of the Volga. If, as is quite probable, the fossils really belong to an extinct species, Owen's specific name, at all events, will have to be used.]

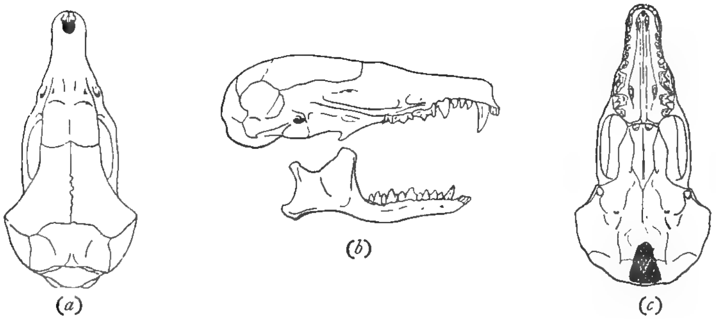


FIG. 27.—SKULL OF *Talpa europæa* :—(*a*) from above; (*b*) from the side; (*c*) from beneath. (Drawn by G. Dollman.)

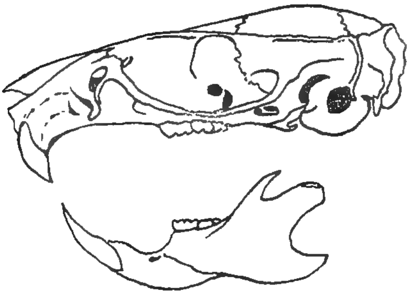
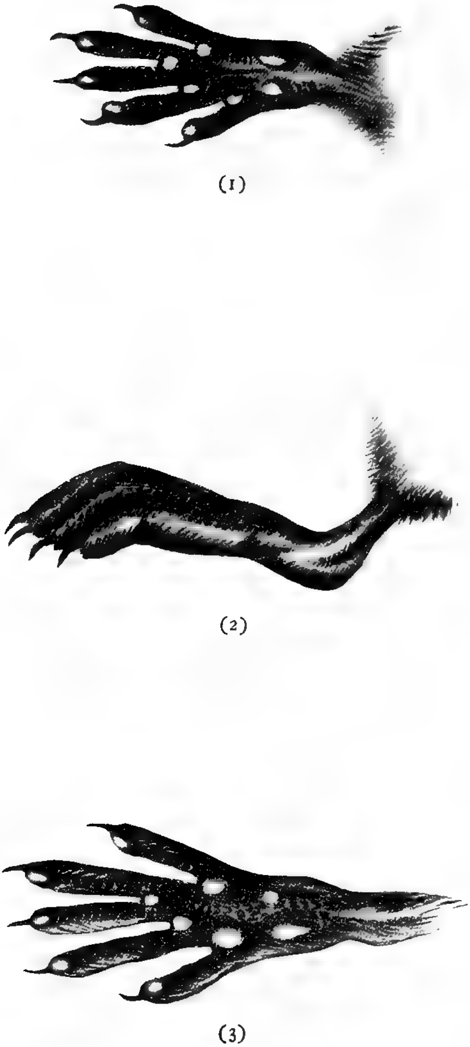


FIG. 28.—SKULL OF *Epimys rattus*, to show "rodent teeth" (life size).

PLATE XI.



WATER SHREW.

(1) LEFT FORE FOOT FROM BENEATH; (2) LEFT HIND FOOT FROM SIDE; (3) LEFT HIND FOOT FROM BENEATH (magnified 2½ times).

RODENTIA.

RODENTS.

Characters:—These are mammals which have no canines, and in which the most prominent and unmistakable character is formed by the large, curved, chisel-shaped, rootless **incisors,** which often have their anterior surfaces yellow or red, and are separated by a long space or diastema from the cheek-teeth, the crowns of which may be tuberculated or laminated. In the **skull** there are zygomatic arches, the central portions formed by the malar bones, and auditory bullæ; the orbits communicate freely with the temporal fossæ; the lachrymal foramina are always within the margin of the orbits, and there are no postglenoid processes to the squamosals. In the mandible the condyle is elongated from before backwards, so that the jaw can be moved backwards and forwards; the symphysial portion is abruptly narrowed and rounded in support of the large incisors, the coronoid process is small and the angular part greatly developed. The radius and ulna are separated; the ischia and pubis are well developed and meet in a long symphysis. The mouth is divided into two cavities; the testes are abdominal or inguinal, becoming more prominent during the rutting season; there are prostatic glands and, except in the Duplicidentata, vesiculæ seminales; the uterus is two-horned; the placenta is discoidal and deciduate; the cerebral hemispheres are smooth, and do not extend backwards far enough to cover any part of the cerebellum; the temporal muscle is comparatively small, the masseter large and double.

This great and well-defined order, which in number of species far exceeds all the others, dates from the Lower Eocene of America and the Middle Eocene of Europe, and possibly had its origin in the Northern Hemisphere (Osborn).

Its members are now found naturally throughout the whole world, excepting only New Zealand and Oceanic Islands, where, however, many introductions have taken place of *Oryctolagus*, *Epimys*, and *Mus*.

Although sharply defined as regards structure, the order includes a great variety of types, displaying very different habits and existing under a great diversity of conditions. Some are burrowers, climbers, swimmers, or jumpers ; others are cursorial, sedentary, or, being provided with parachutes of skin, appear to be in a fair way to attack the problems of flight. With the exception of the actual oceans, there are few parts of the world's surface where rodents have not secured a foothold, and they exist in one form or another in almost all types of country ; being found from the eternal snows of the lofty mountain ranges to the swamps of the great rivers, and from the frozen lands of the north polar basin to the vast burning sand deserts.

By nature primarily herbivorous, they differ from the other great order of herbivorous mammals, the Ungulata, in the fact that they rarely attain to any considerable size. To this fact, together with their extreme fertility and their general readiness to adapt themselves to an omnivorous, to an insectivorous, or even a carnivorous diet, they probably owe the secret of their success as an order, but it should be noted that some species are absolutely restricted to vegetarianism.

All the British representatives give birth to several young at a time, and, usually, to more than one litter in a season, so that, under favourable conditions, their increase is rapid. Except in the case of the hares, all British rodents are born in an undeveloped and helpless state, and are at first well cared for in a warm nest, placed often in an underground tunnel constructed by the mother, and frequently lined with wool or hair plucked from her own belly. The cavies or guinea-pigs, only known in Britain in captivity as domesticated varieties, probably represent the extreme of mammalian precocity, since they will eat cabbage within half an hour of their birth. All grow with great rapidity, and breed as soon as, or before, they are full grown.

They may be gregarious, sociable, or solitary, and the majority seem to be polygamous. Some, like the Squirrel, are monogamous, but they may change their mate at the end of a season.

Many species have been regularly kept in confinement either for their beauty, as the squirrels, rats or mice, or for the use of their fur and flesh, as the Rabbit. All but the first have now been so thoroughly domesticated that there are many distinct artificial breeds in existence; which, however, are quite fertile with each other or with the wild form. Many wild species of rats and mice may also without much difficulty be induced to breed in captivity, but the hares are not easily managed unless they are provided with a run on grass. The Common Squirrel, although it thrives well in confinement, has only been known to produce young in a very few instances, and never in the second generation.

Rodents are subjects of somewhat varied attention by humanity in general, since (to take British examples only) the hares and rabbits are of special interest to the sportsman, the cook, and the furrier; the rats and mice, except by those who keep them as pets, are commonly regarded as vermin. On the other hand, the extinct Beaver was the possessor of most interesting habits, as well as of fur so superexcellent as to be its own undoing; the Squirrel and Dormouse will always attract attention by their beauty and graceful agility. Apart from the utility of the hares and the rabbits as food and objects of the chase, and the value of their fur, as well as of that of the Beaver and Squirrel, little can be said in praise of any British rodent from an economical point of view. The Dormouse alone is innocuous. The Squirrel will be shown to be injurious to woods. All the hares, the rabbits, and the whole tribe of rats and mice are in varying degrees directly harmful to agriculturists, and the Common Rat and Mouse live almost entirely at the expense of man. This is the case especially in England, where their natural enemies, four-footed and winged, have been to so great an extent exterminated by game-preservers. Occasionally under these circumstances one or other of the smaller murines may become so numerous as to occasion what is called a "plague," details of which will be given under the various species. The Common Rat, as well as some exotic species, have recently attained an even more unenviable notoriety, since the discovery that they are the bearers of the disease of the above name to human beings.

From the point of view of the philosophical naturalist, the rodents are in many ways the most attractive order of British mammals. They usually possess a high degree of beauty, both in form and colour, and within their own limits their variety is almost infinite. It is noticeable, for instance, that the order is so plastic that it includes within its ranks several species and sub-species peculiar to Britain. The history of all of these is of special interest.

Amongst the mice there are distinct representatives of specific or sub-specific value in Fair Island, the Orkneys, St Kilda, the Outer Hebrides, and Skomer Island. Almost all the other small rodents of Britain are sub-specifically distinguishable from their representatives on the continent of Europe.

In the matter of pelage the rodents are in many ways remarkable. The varying hares afford conspicuous instances of the phenomenon of winter whitening, the Squirrel of bleaching and of a complicated system of moults, the water and true rats of a tendency to melanism.[1] In some families, as in the *Leporidæ* and the South American chinchillas, the fur is of very fine texture, but in other forms it is replaced by spines on the back, the most extreme instance being that of the (non-British) porcupines.

The Dormouse is subject to hibernation. The Brown Rat and House-Mouse are so closely attached to man as to be almost domestic. The former is admittedly a recent arrival, yet the locality of its origin is unknown. The Rabbit is also not indigenous, although known at least from the twelfth century.

A number of other rodents inhabited the British Islands in past geological ages, and some of these are still represented by their descendants on the continent of Europe.

Structure:—The prominent cutting **incisors** often excite interest by the remarkable deformities or abnormalities which they undergo when injured. Since the pulp is persistent, these teeth continue to grow throughout life. They are strongly curved, especially those of the upper jaw, and are so arranged in opposition as to wear away their cutting surfaces one against the other. If one happens to be broken, great disturbances result. The corresponding tooth in the opposite jaw, having no means of wearing away its cutting edge and finding its growth unchecked, continues to push its head forwards in a circle or spiral, until it may eventually kill the unfortunate animal, either by penetration or starvation resulting from inability to feed. A good figure of such a case occurring in a rabbit was published by Tegetmeier in the *Field*, 8th March 1890, 360.

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[1] See also, for the colour of certain exotic squirrels, below under genus *Sciurus*.

The two **cavities of the mouth** are formed by a folding inwards of the hairy skin of the face behind the incisors. Thus these teeth when engaged in gnawing through an obstacle do not fill the mouth with inedible or objectionable material, as happens when a dog or other animal with a simple mouth uses its teeth to remove roots or soil.

Classification:—The surviving British members of the order as here arranged fall into four families:—*Leporidæ*, containing the hares and rabbits; *Muscardinidæ*, the dormice; *Muridæ*, the mice, rats, and their allies; *Sciuridæ*, the squirrels; and a fifth, the *Castoridæ*, containing the beavers, of which a British representative only became extinct in early historical times. The above families are usually grouped in two main divisions or sub-orders. Of these the *Duplicidentata*, including only, amongst living British rodents, the *Leporidæ*, have always two pairs of upper incisors. The second division, that of the *Simplicidentata*, includes all British rodents except the *Leporidæ*, and its members are easily recognised by their single pair of these teeth. No rodent possesses more than a single pair of mandibular incisors.

An older arrangement whereby the order was divided into groups, each of higher rank than a family, such as *Lagomorpha* or leporines, *Myomorpha* or murines, and *Sciuromorpha* or squirrel-like rodents, has been superseded as being in many ways unnatural and unsatisfactory. Under it, for instance, the dormice must necessarily be placed either with the mice or the squirrels, in either case an unnatural alliance.

DUPLICIDENTATA.

These are rodents distinguished from all other members of their order by the possession throughout life of four upper incisors, in which the enamel extends round to the posterior surface. Two of these are of the ordinary type, but large and heavy; the other two are minute, and, lying behind the larger ones, are concealed from view; a third outer pair is present at birth, but persists for only a short time. The grinding teeth are so arranged that the motion of the jaws in eating is from side to side (see below, description of hares). The incisive foramina are very large and posteriorly confluent, and the bony palate is so reduced as to appear as at most a narrow bridge lying between the premolars.

There are two families, the *Ochotonidæ*, the pikas, tailless- or mouse-hares, and the *Leporidæ*, or hares and rabbits.

[OCHOTONIDÆ.[1]

PIKAS OR MOUSE-HARES.

These are represented in Britain only by an extinct species, *Ochotona*[2] *spelæa*,[3] the bones of which occur in the latest pleistocene cavern deposits.

A member of the family, *O. pusilla* (Pallas), still inhabits the Ural Mountains, and ranges from the Volga to Turkestan and Western Siberia. Other forms are found through Asia to the mountains of western North America.

For our knowledge of the early history and evolution of the *Ochotonidæ* we are principally indebted to Forsyth Major's paper, published in the *Trans. Linnean Soc.* (London), *Zool.*, Nov. 1899, 433-520. The group is first met with in the lower miocene deposits of Western Europe, in which region it not improbably had its origin. At a later date it spread eastwards, and appears to have first found its way to America by way of Asia in the pleistocene period.

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[1] Extinct in Britain.

[2] Of Link, 1795, antedating *Lagomys*, Cuvier, 1800.

[3] *Lagomys spelæus*, Owen, *British Fossil Mammals, etc.*, 1846, 213, figs. 82-4.

The Pikas are about the size of guinea-pigs, and are chiefly found in mountains, where they live in holes in rocks. The living forms differ from the hares in having all four limbs of about equal length, in their short ears, and in the absence of a tail. In the generally depressed skull the contracted frontals are without postorbital processes; the malar bones are drawn out in very long processes behind the zygomatic processes of the squamosals, and more than half of the bony palate is formed by the palatine bones. The clavicles are complete.

The Pikas differ from almost all *Leporidæ* in having only five upper cheek-teeth instead of six; in the mandible there are five or four cheek-teeth. The anterior three of these teeth in the upper, the anterior two in the lower jaw always replace deciduous predecessors, and are therefore premolars. In this the *Ochotonidæ* agree with the *Leporidæ;* and the tooth that is constantly missing is the last upper molar ($m\underline{3}$), but in some forms the last lower molar ($m\overline{3}$) disappears as well. The dental formula of the *Ochotonidæ* is therefore:—

$$i\,\frac{2-2}{1-1},\quad c\,\frac{0-0}{0-0},\quad pm\,\frac{3-3}{2-2},\quad m\,\frac{2-2}{2-2 \text{ or } 3-3} = 24 \text{ or } 26;$$

that of the *Leporidæ* normally:—

$$i\,\frac{2-2}{1-1},\quad c\,\frac{0-0}{0-0},\quad pm\,\frac{3-3}{2-2},\quad m\,\frac{3-3}{3-3} = 28.$$

The suppression of $m\underline{3}$ is a very ancient feature of the *Ochotonidæ*, since it is already seen in the oldest known form, viz., *Titanomys visenoviensis* of von Meyer from the lower miocene. In a middle miocene successor, *T. fontanessi* of Depéret, the last lower molar ($m\overline{3}$) also disappears in adults, and this tooth is entirely suppressed in *Prolagus* (middle miocene to pleistocene). The genera *Lagopsis* (middle miocene) and *Ochotona* (pleistocene and recent), although more specialised than *Prolagus* as regards the structure of the teeth, are more primitive in that they have retained $m\overline{3}$; this tooth being, of course, as elsewhere in Duplicidentata, much reduced.

The dental evolution, and especially that of the upper cheek-teeth, is of considerable interest, and throws so much light on the teeth of other rodents that it may be described in some detail. In common with those of other primitive mammals the cheek-teeth of all the earliest Duplicidentata were short-crowned, or brachyodont, and provided with long and completely closed roots in the adults. As in other mammals, so (and nowhere more strikingly) in the Rodentia—one of the principal directions of dental advance has been that leading to hypsodonty, or long crowns, and persistent growth. In the lower miocene period the *Ochotonidæ* had already made substantial progress along this line. The anterior view of an upper molar of *Titanomys visenoviensis* is given in Fig. 29, No. 1*a*. The outer part of the crown is very low, or brachyodont, and it is supported on two small centrally placed and completely closed roots, of which one is seen in the drawing. The inner part is supported on a single large, but not quite closed root, and is greatly deepened by an extension of its enamel covering over part of the surface of the fang. The next stage is seen in the middle miocene *T. fontanessi*, wherein the brachyodont external part of the crown (No. 2) has atrophied; the small fangs are no longer central but external, and they remain longer unclosed. At the same time the inner part of the crown has become still higher or deeper, and the enamel has invested the whole of the inner face of the enlarged and now constantly open root. Eventually the small external roots are completely absorbed by the large inner one; the large internal root is itself transformed into part of the molar crown by the encroachment of the enamel sheet, and in the end we have the prismatic, persistently growing teeth of the living pikas, and the hares and rabbits. To-day the ancient rooted and brachyodont character is, among Duplicidentata, alone met with in their milk-molars, these being always more conservative than the permanent ones.

Another interesting set of changes call for a little notice, and is illustrated by Fig. 29. The cheek-teeth of *Ochotonidæ* and *Leporidæ* originally possessed a longitudinal pattern of enamel folds; this has been superseded by a transverse arrangement. An upper molar of *Titanomys* shows on its worn surface two crescentic enamel folds each filled with cement, and opening on the antero-external corner of the tooth (Fig.

29, No 1, *b* and *c*), and the inner border of the tooth is indented by a wide notch or groove (*a*), which extends down towards the root. In *Prolagus* the central upper premolar (Nos. 3, 4, $p\underline{3}$) shows what is substantially the same arrangement; but the posterior upper premolar (Nos. 3, 4, $p\underline{4}$) shows a change; in the latter the two crescentic enamel folds (*b* and *c*) have been converted into enamel islets, and the inner notch *a* has become a transverse fold, stretching half-way across the

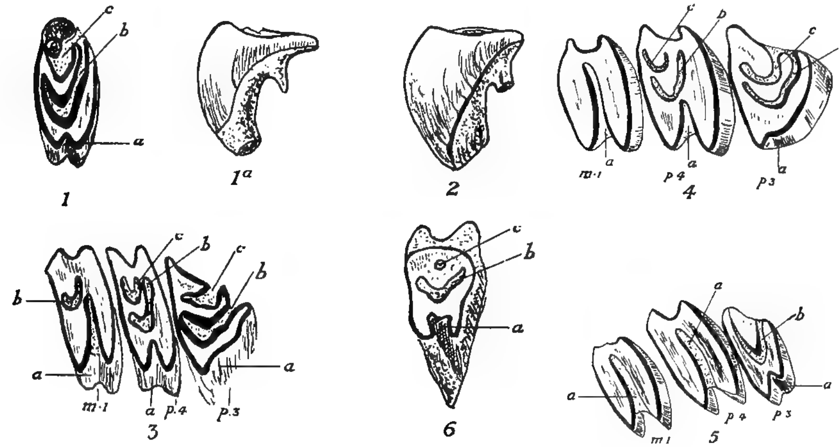

FIG. 29.—UPPER CHEEK TEETH OF *Duplicidentata.* 1, Grinding surface and, 1*a*, anterior view of a molar of *Titanomys visenoviensis* (lower miocene); 2, the corresponding tooth in *T. fontanessi* (middle miocene); 3, 4, 5, grinding surfaces of $p\underline{3}$, *p*4, and *m*1, in *Prolagus œningensis* (middle miocene), *P. sardus corsicanus* (pleistocene), and *Ochotona spelœa* (pleistocene), respectively; 6, grinding surface of a worn milk molar of *Oryctolagus cuniculus* (recent). All represent right teeth; in Figs. 1, 3-6, the left and right sides are posterior and anterior respectively, the bottom and top are internal and external respectively; in 1*a* and 2 the right and left sides are internal and external respectively. (Drawn by M. A. C. Hinton; figs. 1, 2, 3, and 6 after Forsyth Major.)

tooth in *P. sardus* (No. 4). In the earlier species, *P. œningensis* (No. 3), the anterior upper molar ($m\underline{1}$) has lost the outer crescentic fold *c* altogether in adult stages of wear, but the inner one *b* remains as an islet; the transverse fold *a* is still further developed than in the posterior upper premolar ($p\underline{4}$). In the pleistocene *P. sardus*, $m\underline{1}$ has lost both crescentic folds (No. 4), and the transverse fold *a* nearly reaches the outer border, as in the living pikas, and in the hares and rabbits. Thus it is shown that in the *Ochotonidœ* the anterior cheek-teeth are more conservative, the posterior ones more progressive, and the same holds good of the *Leporidœ*, and also of many other rodents.

In the middle miocene *Lagopsis* a still further advance is made, since the posterior upper premolar ($p\underline{4}$) has completely acquired the transverse arrangement; the central upper premolar ($p\underline{3}$) being also in course of reduction. In *Ochotona* (No. 5), the latter tooth, $p\underline{3}$, in adult stages only retains the internal crescentic fold *b*, having completely lost the outer one. In *Leporidæ* this tooth also is fully transformed, and only the anterior upper premolar ($p\underline{2}$) retains any permanent trace of the original pattern. Nevertheless, the milk-teeth, and the unworn crowns of even the permanent teeth, of these highly specialised modern forms still show ephemerally the ancient pattern which characterised the teeth of their miocene ancestors, as shown by No. 6, which represents a worn milk-molar of a rabbit.

Prolagus is in another way of great interest. It makes its first appearance in the middle miocene period, and species are known to occur in the lower and middle pliocene deposits of France and Italy. It is an extraordinary fact that a representative of this tertiary genus, *P. sardus*, managed to survive in the Mediterranean region until the pleistocene period. Remains of this rodent occur in great abundance in the bone breccias of Corsica and Sardinia, and nearly allied forms have been found in similar deposits on the shores of the Mediterranean at Gibraltar, Cette, Rattoneau, Nice, and Mentone. Forsyth Major proved indeed that in Corsica *P. sardus* survived sufficiently long to have formed part of the food of neolithic man.[1]]

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[1] *Prolagus*, Pomel, 1853, antedating *Myolagus*, Hensel, 1856. See Forsyth Major, *Geol. Mag.*, October and November 1905, where numerous references to the literature are given.

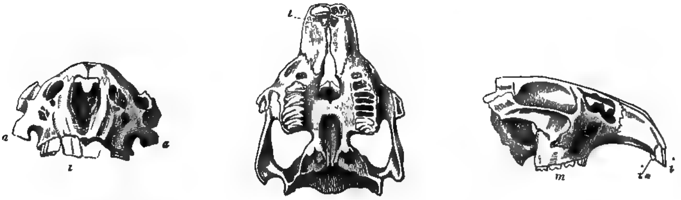

FIG. 30.—SKULL OF *Ochotona spelæa*, from Kent's Hole, Devon. (From Owen's *British Fossil Mammals*, figs. 82, 83, and 84, p. 213.)

LEPORIDÆ.

HARES AND RABBITS.

Characters:—These are duplicident rodents, with long ears[1] and hind legs; with rudimentary clavicles; with the palatal bridge formed mainly by the maxillary bones; with superciliary processes to the frontals; with rather small auditory bullæ not inflated with spongy tissue with lateral mastication.

They appear to have had their **origin** in North America, where they are first known from the lower oligocene (*Palæolagus*). *Lepus* itself appears in the upper oligocene of North America, but is not found in Europe or Asia (Siwaliks) until the lower pliocene.

They are now widely distributed, being represented all over the world, except in New Zealand, Australasia, and Madagascar.

Classification:—This family formed until recently one genus, *Lepus*. It has latterly, however, like other groups, been compelled to yield to the attack of minute study, and the old Linnean genus has already been divided into about ten modern genera, including many species and sub-species.

The first and most obvious segregation was that of Forsyth Major, who, in the *Trans. Linnean Soc.* (London), *Zool.*, Nov. 1899, 514, 1900, placed the hares and rabbits in two super-generic groups. One containing the genus *Lepus* included the brown hares and their allies of Europe and Asia, the jack rabbits of North America and the arctic regions, and the varying hares of both continents. The other, which he styled *Caprolagus*, embraced all other forms. Later writers, however, such as Lyon, *Smithsonian Miscellaneous Collections*, xlv., 389, 15th June 1904, and Nelson, *N. Amer. Fauna*, No. 29, 31st August 1909, consider that Forsyth Major's group, *Caprolagus*, includes several genera not less clearly defined than *Lepus.* Only one of these, *Oryctolagus*, containing the rabbit, affects British naturalists.

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[1] Abnormal specimens are not unknown both of rabbits and hares in which the external ears are defective or absent, and there are two such examples of rabbits in the Museum of the Royal College of Surgeons, placed there by Tegetmeier, and for particulars of which I am indebted to Burne. See Milroy, *Field*, 9th January 1904, 51; Bird, *Field*, 30th January 1904, 139.

Further subdivision of the large and unwieldy genus *Lepus* is inevitable, but has not hitherto been successfully effected. A commencement may be made with the Greenland Hare, *L. grœnlandicus* of Rhoades, which is thoroughly differentiated from any other known form, and I propose to assign it to a new genus—*Boreolepus*—based specially on its protruding premaxillary region and large slightly curved upper incisors which stand out clear of the skull when viewed from above. These characters, together with the stout fossorial claws, heavy wool-like coat and permanent white (or whitish) colour, affecting both hair and underfur, form a combination denoting extreme specialisation to suit very unusual conditions —for the animal has to scratch and pull out its food from under snow (see Manniche, *Mammals of North-East Greenland*, 1910, 31)—and unapproached by any other known hare.

The Greenland Hare is a remarkable instance of adaptation to the intense arctic conditions in which it exists. Inhabiting the permanent snowfields of the north coast of Greenland and Ellesmere Land, on which it is the companion of the Northern Musk Ox, *Ovibos wardi*, it penetrates beyond 83° north latitude as far towards the Pole as terrestrial mammals can exist. In spite of the rigorous climate it is a large form, reaching a weight of 8 to 10 lbs. (Feilden). Although it produces only one set of young in the brief arctic summer, these are numerous enough to equal the combined product of two or three litters of some of the southern species, for Feilden (*Zoologist*, 1877, 354, and Appendix to Nares's *Voyage to the Polar Sea*, 1878, ii., 204) records seven to eight young; and Fabricius (*Fauna Grœnlandica*, 1780, 25) eight.

There are four **British species** of *Leporidæ*, the arrangement of which in the present work and in Bell's *British Mammals* is shown below :—

Bell's system of 1874 :—		*System of present work* :—
(1) LEPUS TIMIDUS	becomes	(2) LEPUS EUROPÆUS OCCIDENTALIS.
(2) L. VARIABILIS	”	(3) L. TIMIDUS SCOTICUS. (4) L. HIBERNICUS.
(3) L. CUNICULUS	”	(1) ORYCTOLAGUS CUNICULUS.

The numbers indicate the order in which the animals are arranged in the two works.

General characters of hares and rabbits:—The hares and rabbits are remarkable for their combination of primitive and specialised characters. Thus, although in the comparatively greater number of teeth their dental formula is very primitive as compared with that of other rodents, the individual cheek-teeth (to be described under genus *Lepus*) have undergone the most profound specialisation. The ears are very prominent and efficient, while the skeletons of the limbs resemble in certain respects those of the swift-footed ungulates. The form of the distal articulation of the humerus is similar to that of the horse, and in the more highly developed forms the ulna is reduced and the radius becomes longer than the humerus.

The hind feet are long, powerful, and efficient, and in rapid progression they are almost the sole propelling power, the action of the fore limbs being then merely accessory (see Tracks and spoor, below, p. 168). All four feet are thickly clothed with fur, so that the animals can pass with ease over snow or smooth slippery surfaces; hence the old Greek name δασυπους (dasypod) as used by Aristotle (*Historia Animalium*, ed. Thompson, 1910, iii., 12, 519^a, 23). They thus differ entirely in their construction from the corresponding members in fast carnivora, the weight of which is supported on a series of elastic pads; and from the ungulates, in which a development of the horny nails is called in for the same purpose. Probably the leporine type is the most successful of the three, since it avoids the wounding and soreness caused to bare padded feet, such as those of fast dogs, on very hard ground; but in many of the northern carnivores a compromise is effected by a considerable growth of hair between the pads. Animals with bare padded feet, such as foxhounds or greyhounds, cannot work in time of frost, and on hard ground the hoofs of horses soon wear away if not shod, and their legs suffer from the jars of constant work; similarly, cattle become very footsore if driven far on roads. Under the same conditions the constantly renewable hairy covering of the leporine foot does not wear away with much usage, and it is superior to both pad and hoof as a lessener of shock to the leg as a whole, and as securing a grip on slippery or rocky ground. But on moderately soft, wet, or sticky ground the feet of carnivores and ungulates are superior, especially those with more than one toe, which can be spread out so as to prevent sinking in mud; while those of leporines may become clogged. The leporine foot may thus have had its origin in an animal frequenting rocks, hard plains, or snow.

The **fur** consists of three kinds of hairs—viz., (1) a short, thick, soft wool or underfur, which is mainly concealed by (2) an abundant set of strong hairs, generally annulated, which push through the underfur and overlie it. These are largely responsible for the external colouring of the animal, but their influence is modified by (3) a third set of hairs, also for the most part annulated, which are sparsely scattered over the body, and longer than either of the other kinds. These are present in their fullest abundance only in the adult, and their tips wear away when the coat becomes old. The fur as a whole is most abundant on the back, and least so, although longest, on the abdomen. Its denseness varies with the season and weather, being thickest in winter and thinnest in summer.

At the back of the neck and over the area covered by the ears the underfur alone is present in British species, and, having usually a distinctive coloration, forms a patch, which, if the ears be raised, shows up very conspicuously.

Nelson finds three **age-pelages** in American forms:—(1) a soft woolly *juvenal pelage*, which is comparable to the downy plumage of young birds, and which gives way when the animal is less than half-grown to (2) the *post-juvenal pelage*. In the latter, which is usually carried until the animal is nearly adult, the middle coat of hair is much more developed than in the *juvenal pelage*, but it is finer than in adults, and the long outer hairs are mostly lacking. These three pelages are undoubtedly present in the Scottish and Irish Hares, but their existence in the Brown Hare and the Rabbit has not been demonstrated, and, even if present, they are certainly not conspicuous.

There are two annual **moults** in all northern forms, and the colour-changes which accompany them may be more or less conspicuous according to the climate. Many forms are white in winter, but dusky or brown in summer, and the change of colour may affect both the hairs and the underfur, or only the hairs; others (including *Oryctolagus*) undergo only a partial whitening in winter. Southern forms do not whiten at all, and in some cases, as in the American subgenus *Macrotolagus*, which includes the Black-tailed Jack Rabbits of Mexico and the Western United States, there is only one moult, usually in late summer or autumn. Individuals of the same species may at different parts of their range exhibit all the different steps between complete winter whitening and the opposite condition; this being the case with *L. europæus*, and almost so with the American White-tailed Rabbit or Prairie Hare (*L. campestris*). A feature of the moulting period is the falling out of the old dead hairs in blocks so as to expose the underfur and temporarily alter the colour of the animal. Similarly, unexpected colour effects are produced by the wearing away of the black tips of the hairs and by bleaching, but the latter process is not conspicuous in British hares. In addition to the regular moults, many of the hairs may be cast and replaced at any season of the year.

The **colour** is evidently very plastic and liable to be influenced by climate; species inhabiting deserts are paler and greyer, while those of humid regions are darker and have the buff or rusty shades deeper and richer. The arctic hares of America are tricoloured, with the flanks darker than the back; but other American species have the sides lighter, and in the White-sided Jack Rabbits of the *Lepus callotis* group the conspicuous white flank-area can be shifted at will on to the back, so as to form a directive signal (Nelson, *op. cit.*, 25-26).

Age characters:—Hares and rabbits grow rapidly and breed at a very early age, even before they are fully grown. It is not easy to distinguish perfectly adult individuals, and inability to do so has led to many mistakes, although careful instructions on this point have been handed down for generations from old writers.[1] Apart from the pelage, which will be described under each species, the young have usually been distinguished from the adults by a number of characters. The ears tear easily, the cleft of the lip is narrow, the claws are smooth, short, and sharp, the under-jaw breaks easily if the two divisions are pressed together at the posterior end, and the heads (epiphyses) of the bones of the "knees," which are really the wrists or carpal joints, of the fore legs, are not fused, so that the thumb-nail may be inserted between them. In old animals the ears are dry and tough, the cleft of the lips is spreading, the claws are long, blunt, and rugged, the under-jaw will not easily break, and the heads of the bones of the carpal joints are so close together as to leave no space between them large enough for insertion of the thumb-nail.

After a careful examination of the above points, I find the tearing of the ears the most useful test of complete maturity, and it is one that is in use amongst poulterers. The ears remain "tender" after the jaw has become sufficiently ossified to resist reasonable pressure. Dimensions are not very reliable, for the animals vary a good deal in different localities, and it must be remembered that the vast majority of hares and rabbits are immature, so that old individuals may almost be regarded as exceptional.

White spots on the forehead are rather frequent in all the British species, and are by some regarded as indicative of youth, by others of mature age (as by Drane in the case of the Brown Hare), and they actually appear to be characteristic both of the very young and very old. A fanciful notion that they are connected with the number of young in a litter does not appear to possess any real value.

In the skull the superciliary processes of the frontals probably afford the best means of distinguishing between young and old. These processes are at first slender and narrow, and their free ends enclose well-marked spaces. Later they grow broad and heavy and the tips may meet and fuse with the skull so as to enclose foramina, or their inner borders may coalesce along their whole length. The growth is gradual, and forms no exact indication of the moment when the animal becomes adult. But it will be found that not only does the process grow towards the skull, but the spot at which it will fuse with the frontal bone prepares itself as it were by roughening and then forming a knob. The roughening of the future point of fusion for the posterior process will be found, as Miller informs me, to be a reliable indication of maturity.

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[1] "Men know by the outer side of the hare's leg if she is passed a year. And so men should know of a hound, of a fox, and of a wolf, by a little bone that they have in a bone which is next the sinews, where there is a little cavity." (*The Master of Game*, translated from the French of Gaston de Foix of about 1387, Baillie-Grohmann's ed. 1904, 12, writing probably of the pisiform bone and the tendon of the flexor carpi ulnaris.)

Sex characters:—Males, sometimes even when quite small, have distinctly thicker and shorter heads than females, their ears often seem to the eye shorter and thicker, and, when of full size, torn from fighting. The head of the female, whether viewed from in front or from the side, is built on distinctly finer lines, so that the sex of an individual can usually be ascertained from a glance at the head.

The demeanour of a male, restless, excitable, quarrelsome, sniffing the ground, and never the leader of a party, frequently betrays his sex.

Weight:—In hares old females are often heavier than the heaviest males, but most observers find these relations reversed in the Rabbit, but in any species an emasculated male would no doubt reach a weight greater than that of any female; the average weight for a series of either sex is sometimes approximately equal, and might be absolutely so if the influence of a sometimes perpetual breeding-season could be discounted.

Distribution:—In contrast to bats, which decrease in number of species from the continent of Europe, westwards to Ireland, the British Islands, taken as a whole (but not any of the three kingdoms individually) are richer in species of *Leporidæ* than any of the neighbouring countries of Europe. This is due to the possession by Ireland of a peculiar species in the Irish Hare, as well as to the fact that in Great Britain the ranges of the Brown and Blue Hares meet and overlap. The latter position is now repeated in Skandinavia, owing to the introduction by sportsmen of the Brown Hare, but it is not a natural condition elsewhere in western Europe.

Of the four British species, one only, the Rabbit, is found in all three kingdoms, but its presence is everywhere due to introduction some time during the historical period. The Irish Hare is indigenous and peculiar to Ireland, and the Brown and Scottish Hares are found as sub-species closely allied to, but just distinguishable from, those of continental Europe. The **abundance** of all four depends largely on the treatment meted out to them by man. In many localities their numbers have undergone a considerable decrease. As against this, it is undoubtedly true that the Brown Hare shows a tendency to extension of range and increase of numbers in the wilder parts of Scotland, while the Scottish Hare, helped to a large extent by introduction, has spread southwards, and now thrives and multiplies on many mountains lying far to the south of its natural range. Irish hares have been freely introduced into Britain, and Brown and Blue into Ireland, and there are now localities where all three may be found on the same ground. Where not killed off by man, the numbers of hares and rabbits may become so great as to result in much inconvenience and loss to property.

Food:—These animals are about as purely vegetarian as any known mammals; the only exception known to me being that of rabbits eating snails. But their range of diet is, within its own limits, comparatively wide, and embraces all the digestible parts of plants, from the bark of young trees to roots, grain, berries, and tubers.

They do not **chew the cud**, as supposed by the ancient Hebrews, but, according to Drane, have the remarkable habit of passing most of their food twice through the body (see below, under Brown Hare). This observation is attributed by Bingley (p. 314) to Cartwright also (*Journal on the Coast of Labrador*, 1792) for tame rabbits, but the latter work is without an index, and I have been unable to find the reference.

They **drink** seldom, but this is no doubt because their food is frequently so wet that they must take in with it comparatively large quantities of water.

Droppings:—These are dry and of a characteristic round form, resembling somewhat those of goats and sheep, but differing in their size and in the, at all times, complete individuality of each pellet. When fresh they are sticky and dark in colour, but soon become lighter and drier, and show the nature of their contents, namely, the indigestible portions of herbage.

Habits:—The habits of hares and rabbits are very variable. Hares are solitary, or at least not sociable. Even if feeding together they separate if pursued, and trust to the secretions of their glands for again discovering each other. Rabbits are very sociable and live in large parties; they have no glands, since they do not normally stray far away from their burrows. Where food is abundant, few species wander much, but spend a life of peaceful monotony, feeding for the most part by night, and sleeping or playing in the hours of daylight. Those inhabiting mountains or cold districts may migrate to milder or more sheltered districts in winter; and more extensive movements have been reported and are, no doubt, due to exceptional circumstances, such as scarcity of food perhaps consequent on overgrowth of population.

The prey of all carnivorous animals and birds, the hares exhibit a rare combination of speed with staying powers, together with exceptional powers of dodging and outmanœuvring an enemy of superior pace. So secure are they, that the Brown Hare rarely seeks better shelter than a wood or thicket. Blue and Irish Hares more readily hide in holes, but no British hare constructs a permanent burrow. All of them will keep on running from an enemy until they die. But rabbits, although also possessed of considerable, although inferior speed, trust for safety to burrows, which they readily dig for themselves.

In accordance with the above differences of habit, the young at birth differ considerably. Those of the British hares being born above ground, without artificial nest of any kind, are fully formed miniatures of their parents; those of the rabbit, being dropped in the recesses of a (frequently special nesting) burrow, are at first naked, blind, and deaf; they repose on a warm bed made partly of their mother's own wool, and are at first safely blocked up in the burrow by her. The habits of some exotic species are intermediate in that, although the young are born above ground like those of our hares, they are placed in a nest like that of a rabbit.

The animals are polygamous, or rather promiscuous breeders. They generally produce several young at a birth, and the numbers of litters that may issue from a single female is limited only by time, climate, and food supplies. The increase is, therefore, rapid. There seems to be some correlation between fertility and latitude; that is to say, northern forms produce fewer but large litters, whereas with southern forms the breeding season is almost perpetual.

Superfœtation has long been known and mentioned by many writers, including Herodotus (born B.C. 484; History, bk. iii., ch. cviii.), Aristotle (born B.C. 384; *Historia Animalium*, ed. Thompson, v., 9, 542^b, 33, 1910; Pliny,[1] and Sir Thomas Browne. The truth is, that in animals with a double uterus such phenomena are possible, but apparently of quite rare occurrence (see under the species), or they would be more frequently reported.

Voice:—Although usually supposed to be silent animals, the members of this family possess a comparatively varied vocabulary, the sounds in which they indulge varying from grunts to loud screams.

A remarkable **stamping of the hind feet** as an expression of excitement is characteristic of all British species, and probably of many exotic also, since it is practised by the American *L. americanus* (see below, under Scottish Hare).

Tracks and spoor:—These are very characteristic. When seen clearly, as on snow or mud, the pattern suggests a series of roughly formed, somewhat triangular figures, with more or less space between each. The sides are not filled in, but the positions of the angles are marked by the impressions of the four feet. Those of the two hind feet, which are long, mark the base of the triangle, while the two roughly spherical marks of the fore feet show the apex. When the animal is at rest the whole hind foot presses the ground so that the mark made is approximately the length of the foot. The fore feet then make contact either between the hind feet or only slightly in front of them, so that no triangle can then be traced, or it is very flat, and its apex points in the direction in which the animal is moving. When the animal begins to run, much lesser portions of the long hind feet touch the ground; but they are now thrown forward in advance of the shorter fore feet, and the triangle then points the other way. The space between the triangles increases with the pace, and the fore feet tend to be brought into a single straight line, thus removing or obliterating the triangles at extreme speed. Except on snow a perfect series is rarely seen, and usually the tracker must be content with the more or less imperfect impressions made by single feet at gateways or in other places where the ground is bare and soft. Such impressions are sometimes limited to the pricks of the claws, the disposition of which indicates whether the foot was a right or left, fore or hind. The size of the impressions is the only guide as to the species; the tracks of a rabbit are much smaller than those of any hare, and the print of the pads of the feet is less clear in the case of the lighter animal.

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[1] Lepus omnium praede nascens, solus praeter dasypodem superfoetat, aliud educans, aliud in utero pilis vestitum, aliud implume, aliud inchoatum gerens pariter—*Naturalis Historia*, viii., 55.

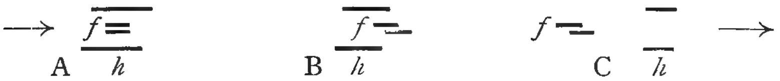

FIG. 31.—DIAGRAM OF SPOOR OF A HARE OR RABBIT.

A, sitting. B, moving slowly forwards. C, moving faster. *ff*, impressions of fore, and *hh* of hind feet. The arrows denote the direction in which the animal is moving. [The diagram is after one which appeared in the *Field* of 27th February 1904, 362, signed " R. C."]

It is evident that the part played by the fore legs in progression is comparatively unimportant. The main driving power comes from the powerful hind legs, and the short fore legs are merely accessory, their function being to give that continuity of action which is absent from a purely hopping or jumping animal. As stated above, the marks made by the fore feet tend to fall one in front of the other, but the hind legs remain approximately together. The animals, therefore, walk and trot with their fore, but leap only with their hind legs. Their movements only partially resemble those of the kangaroos, jerboas, and other hopping mammals; but in this connection it should be noted that Manniche (*op. cit. supra*, p. 160) describes the Greenland Hare as hurrying up a hill in rapid jumps, "moving on the tiptoes of the hind limbs, while the fore limbs either dangled in the air or were kept close to the breast."

Hares, and even more so rabbits, habitually travel over the same ground in going to their feeding-places, so that the herbage over which they pass becomes worn down and a recognisable path or run is formed. The characteristic of these runs is their unevenness. The animals proceed by a series of leaps, and, if undisturbed, not only do they use particular tracks, but they generally make a leap of about the same length at the same place. The result is that the ground where they alight is worn bare, while the herbage has an opportunity of growing at the intermediate places which they leap over in their stride. It follows that the pace at which the animals are accustomed to travel at any one part of their runs can be calculated without difficulty by observation of the distance between the worn patches, and this knowledge is very extensively utilised by trappers and snarers.

Hares and rabbits all over the world seem to be subject to **epidemics,** the exact nature of which is not necessarily similar in different regions. In North America the various species seem to go through a regular routine. First they become excessively abundant, so that the numbers of *Lepus americanus* have been estimated by Thompson Seton (i., 640), at ten thousand to the square mile; then a fatal disease breaks out, and within two years or so they almost totally disappear from vast areas. During the continuance of an epidemic fertility decreases, and fewer young are born. But, as soon as it has worn itself out, there is a "periodic" increase, and females may produce as many as six, eight, or even ten at a birth (Nelson, *North Amer. Fauna*, No. 29, 1909, 23-24; see also Preble, *op. cit.*, No. 27). Similarly, in Britain, overstocking of ground usually leads to an outbreak of disease, which is for a time very fatal, but not of long duration.

As compared with some other British mammals, shrews for instance, the rabbits are very recuperative and **hardy** and do not succumb easily to injuries, such as the loss of a leg; but hares die readily from shot wounds, or if even slightly bruised on the loins, or if run hard.

When the food is succulent the **flesh,** although varying much in the different genera, is generally excellent eating, but it is of poor quality when, as in arctic regions, the animals subsist only on rough herbage or the bark of trees.

A KEY TO BRITISH LEPORIDÆ.

I. EXTERNAL CHARACTERS:—

I. Ear when bent forwards reaches far beyond tip of nose	*LEPUS europæus.*
II. Ear when bent forwards reaches about to tip of nose:—	
1. Hind foot about equal in length to tail, including hairs . . .	*ORYCTOLAGUS cuniculus.*
2. Hind foot much longer than tail, including hairs (in young specimens double)—	
A. General colour ochraceous or tawny; hind foot to 165 mm.	*LEPUS hibernicus.*
B. General colour deep brown or smoky (in winter whitish); hind foot to 155 mm. . .	*L. timidus scoticus.*

II. TEETH AND SKULLS:—

I. Course of root of upper incisor not visible externally; length of bony palate greater than width of posterior nares, which are narrow	*ORYCTOLAGUS cuniculus.*
II. Course of root of upper incisor visible externally; length of bony palate less than width of posterior nares, which are very wide	*LEPUS.*
1. Root of upper incisor not reaching premaxillo-maxillary suture; distance between anterior edge of zygoma and anterior termination of external groove greater than least depth of arch . . .	*LEPUS europæus.*
2. Root of upper incisor passing premaxillo-maxillary suture; distance between anterior edge of zygoma and anterior termination of external groove less than least depth of arch—	
A. Skull larger — occipito-nasal length to 95 (or more) mm. .	*L. hibernicus.*
B. Skull smaller — occipito-nasal length to 90 mm. . .	*L. timidus scoticus.*

GENUS ORYCTOLAGUS.

1758. LEPUS, Carolus Linnæus, *Systema Naturæ*, x., 57 ; xii., 77, 1766 (part) ; based on *L. timidus* of Linnæus—type, see Thomas, *Proc. Zool. Soc.* (London), March 1911, 145—*L. cuniculus* of Linnæus from Europe, and two other species.

1790. CUNICULUS, F. A. A. Meyer, *Mag. für Thiergeschichte*, I., i., 52-53 ; see also Gloger, *Gemeinnütziges Hand- und Hilssbuch der Naturgeschichte*, I., 104, 1842 ; Gray, *Ann. and Mag. Nat. Hist.*, September 1867, 224 ; based on *Lepus campestris* of Meyer = *L. cuniculus* of Linnæus, but preoccupied by CUNICULUS of Brisson, *Regnum Animale*, 1762, 13, a genus of *Dipodidæ*, and by CUNICULUS of Wagner, *Natürliches System der Amphibien*, 1830, 21, a genus of *Muridæ*.

1874. ORYCTOLAGUS, W. Lilljeborg, *Sveriges och Norges Ryggradsdjur*, i., 417 ; a subgenus of *Lepus*, replacing the preoccupied CUNICULUS, and based on *Lepus cuniculus* of Linnæus ; Trouessart ; Forsyth Major (part) ; Thomas, *Ann. and Mag. Nat. Hist.*, January 1903, 78-79 (genus) ; Lyon (genus) ; Nelson (genus).

The **synonymy** is simple.

Classification :—The generic separation of the hares and rabbits, although only recently accepted, is supported by such a long list of distinctive characters that a perusal of them will surely be the best argument in its favour.

The true rabbits, of which one wild species is known, are active terrestrial rodents, of almost exclusively vegetarian and predominantly graminivorous diet. They prefer a mixed country, where an alternation of open fields and woods affords them both food and shelter. They usually construct and inhabit burrows, and differ from the hares (see genus *Lepus*) in their plumper, more rounded body, shorter hind limbs, longer tail, simpler pelage not subject to marked seasonal changes, and in the white flesh, which resembles that of a common fowl. They are extremely prolific, and drop their blind and naked young underground. They do not usually wander far from their burrows, and are unprovided with "recognition glands." The structure of the forearm is primitive and not specially modified either for speed, as in the hares, or, as might have been expected, for digging—see Forsyth Major, *Trans. Linnean Soc.* (London) *Zool.*, Nov. 1899, 433, etc., published 1900. This accounts for the fact that rabbits sometimes dispense with burrows in hard soils.

The **mammæ** may be three or more pairs.[1]

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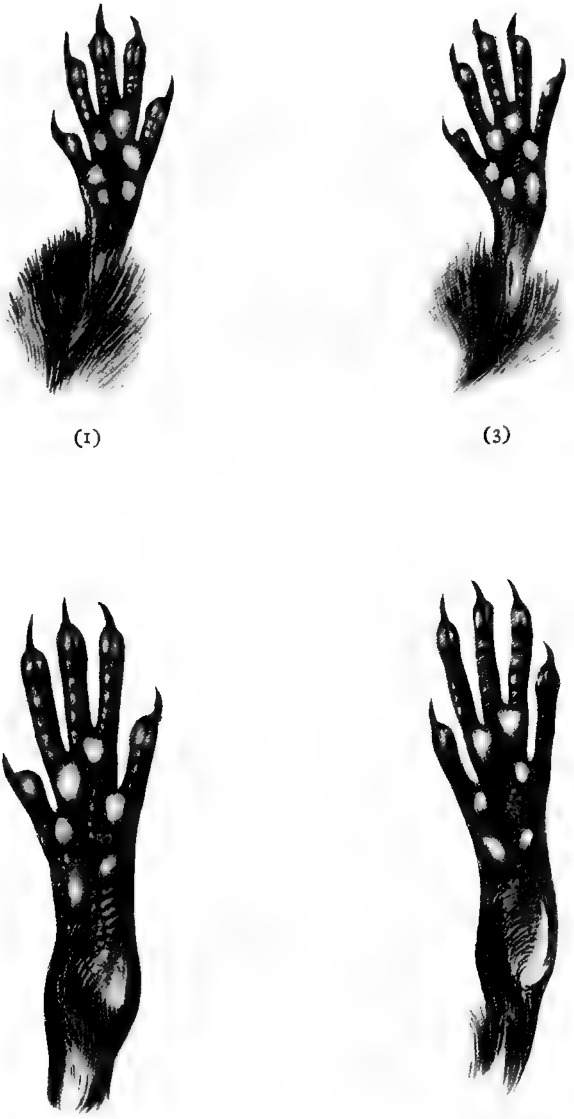
[1] Darwin, *Variation of Animals and Plants under Domestication*, 1868, i., 106, gives the number for the domestic variety known as the "Belgian hare" as six (*i.e.*, three pairs), and for other domestic forms as variable.

PLATE VIII.



(1) (3)

(2) (4)

Common Shrew.—(1) Left Fore and (2) Left Hind Foot (magnified 4 times).
Lesser Shrew.—(3) Left Fore and (4) Left Hind Foot (magnified 4½ times).

Rabbits are known from the upper **pliocene** of central France and Italy by *O. lacosti* (Pomel); and from pleistocene deposits of Britain and continental Europe. Hinton has recently examined some bones from the pliocene Forest Bed of Norfolk, which are probably to be referred to *O. lacosti*. His description will appear later.

This small but well-marked genus was formerly known only from the Iberian Peninsula, the Balearic Islands, and southern France; thence it has spread naturally, or by introduction, to the greater part of temperate Europe. It has, besides, been artificially introduced in many localities, especially islands, all over the world. The only recent wild species, the well-known *O. cuniculus*, is easily domesticated, and has given rise to many distinct and stable artificial forms, all of which show the true generic characters, in some cases even more markedly than the parent stock.

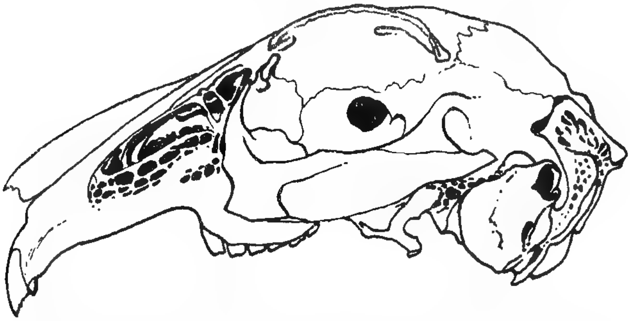


FIG. 32.—SIDE VIEW OF SKULL OF *Oryctolagus cuniculus* (life size).

Oryctolagus has no close relationships with Old-World genera. According to Lyon, it comes nearest in structure to the North American cottontails of the genus *Sylvilagus*, in which the young are also born blind and naked (Nelson, *North Amer. Fauna*, No. 29, 1909, 14); some species at least have the mammæ as in *O. cuniculus* (Nelson, *in lit.*), the flesh is white (*fide* Nelson, and Preble, *in litt.*), and the sexes appear to be approximately equal in size (Nelson, *in lit.*). *Sylvilagus*, however, differs widely from *Oryctolagus* in skull characters, and does not habitually construct its own burrow (Nelson, *op. cit.*, 22); and in *S. floridanus* at least, inguinal glands are present, as in *Lepus*.

In the **skull** (as compared with *Lepus*) the superciliary processes of the frontals are slender, and not wide or distinctly triangular. In some specimens of domestic forms an anterior notch may become a foramen by junction of the anterior angle with the frontal bone; occasionally an anterior angle may be completely fused to the cranium, thus obliterating even a foramen (see also Figs. 44 and 45).

The interparietal bone is distinct throughout life.

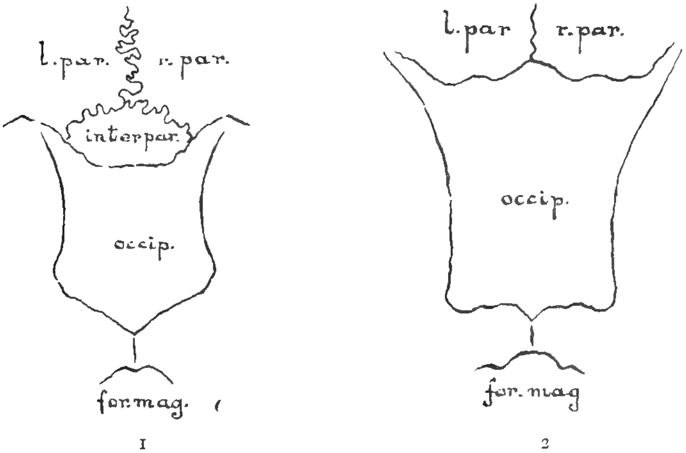


FIG. 33.—Diagram showing interparietal region of skull in—(1) *Oryctolagus*; (2) *Lepus*, in which the interparietal bone is absent in adults (both slightly magnified).

l. par. = left parietal; *r. par.* = right parietal; *occip.* = occipital; *for. mag.* = foramen magnum.

The bony palate is relatively long, its length being greater than the width either of the posterior nares or of the incisive foramina, both of which are narrow, especially the former. The parts of the palatine bones bordering the maxillæ below the posterior edge of the bony palate are better developed than in *Lepus*, and form part of the roof of the mouth along the posterior dental alveoli.

The anterior portions of the zygomata are deeper than the posterior. The foot-like extremities of the zygomatic processes of the squamosals are enlarged, so that the lateral length of a squamoso-malar suture is about one or one and a half times less than that of the superior border of its malar, measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit. The posterior free projecting extremities of the malars are large.

The mandible is characterized by the large size of the mental foramina, which are situated nearer to the cheek-teeth than in *Lepus*.

The **teeth** are as in *Lepus* (see below), but the longitudinal grooves of the large upper incisors are shallow, and never filled with cement. These teeth are more deeply implanted than in *Lepus europæus*, although less so than in the varying hares; the course of their roots can only with difficulty be seen externally.

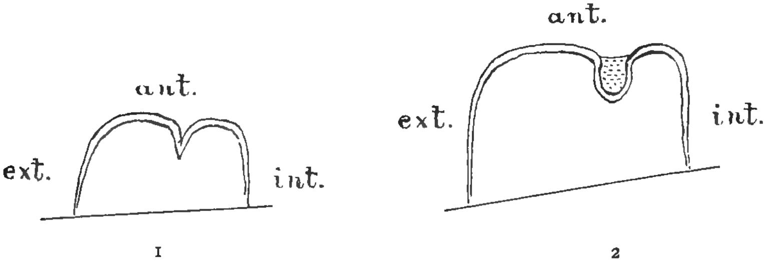


FIG. 34.—Magnified diagrammatic view of transverse section of anterior surface of a large upper incisor of (1) *Oryctolagus*, and (2) *Lepus*, to show the longitudinal groove and the cement with which it is usually filled in *Lepus*. Ant. = anterior; int. = interior; ext. = external.

In the **skeleton** the cervical vertebræ are uniformly shortened; the costal processes project comparatively far from their centra, and the anterior and posterior spines are less pronounced.

The lumbar vertebræ have transverse processes of the same relative length and width as in *Lepus*, but they do not rise abruptly from the anterior half of their centra; besides the anterior attachment, each has also a rather long posterior root following nearly the whole of the posterior half of the centrum, and sharply sloping into the process itself.

There are sixteen to seventeen caudal vertebræ.

The anterior ribs have the shafts only moderately enlarged ventrally.

The scapulæ are relatively narrow, with their superior borders straighter and less convex, the antero-superior angles relatively pronounced and not so gradually rounded as in *Lepus*, and the supra-spinous fossæ relatively narrow.

The ulnæ are very strong, and lie alongside the radii. The humeri are about equal in length to the forearms.

THE RABBIT OR CONY.

ORYCTOLAGUS CUNICULUS (Linnæus).

1666. CUNICULUS, a CONEY, Christopher Merrett, *Pinax*, 168.

1693. "CUNICULUS, Δασυπȣς, a Rabit or Coney," John Ray, *Synopsis Methodica Animalium Quadrupedum*, etc., 205.

1758. LEPUS CUNICULUS, Carolus Linnæus, *Systema Naturæ*, x., 58 ; xii., 77, 1766 ; described from *Europa australi*, *i.e.*, probably Europe south of Sweden ; Berkenhout ; Turton ; Bingley ; Fleming ; Jenyns ; MacGillivray ; Keyserling and Blasius ; Clermont ; Flower and Lydekker ; Lydekker ; Millais.

1790. CUNICULUS CAMPESTRIS, F. A. A. Meyer, *Mag. für Thiergeschichte*, i., 1, 52-53, renaming *L. cuniculus* of Linnæus ; not *Lepus campestris* of Bachman, 1837.

1820. LEPUS CANICULUS, E. Donovan, *Natural History of British Quadrupeds*, etc., plate xviii. (includes both tame and wild forms).

1837. LEPUS VERNICULARIS, William Thompson, *The Athenæum*, 468 ; named from Ireland, but without description, hence a *nomen nudum*.

1842. CUNICULUS DASYPUS, C. W. L. Gloger, *Gemeinnützige Hand- und Hilssbuch der Naturgeschichte*, i., 104, renaming *L. cuniculus* of Linnæus.

1867. CUNICULUS FODIENS, J. E. Gray, *Ann. and Mag. Nat. Hist.*, September, 225, from Klein.

1874. ORYCTOLAGUS CUNICULUS, W. Lilljeborg, *Sveriges och Norges Ryggradsdjur*, i., 417 and 441 ; Trouessart ; Forsyth Major ; Thomas (1903) ; Johnston ; Lyon ; Nelson ; Trouessart (1910).

Le Lapin of the French ; *das Kaninchen* of the Germans.

Sex names :—Buck and doe.

The **synonymy** is that of the Wild Rabbit, a subject which, apart from the use of the term *Oryctolagus*, already treated under the heading of the genus, is usually considered to be quite simple. Thomas has, however, shown in *Proc. Zool. Soc.* (London), 1911, 145, that in the earlier editions of Linnæus's *Systema Naturæ* (as the 6th, 9, No. 2), the description of *Lepus cuniculus* was clearly based on an albino domestic rabbit with red eyes—*pupillis rubris*. Later on Linnæus became acquainted with the Wild Rabbit, and the words *pupillis rubris* no longer appear in his 10th edition. Instead, the sentence "Habitat in Europa australi," indicates that Linnæus, disregarding his original intention, now meant to indicate the Wild Rabbit, which is fortunate for posterity, as, if it had been necessary to regard the word *cuniculus* as applicable only to a domestic rabbit, a confusing change in nomenclature could hardly have been avoided. It is remarkable that, long before the era of nomenclatural troubles, Linnæus's meaning was discussed by Daines Barrington (*Phil. Trans. Roy. Soc.*, London, lxii., 1772).

The technical name or names of the domestic forms of rabbit are not of importance for present purposes. The name *nigripes* applied by Bartlett to the "Himalayan" variety is, however, available (see below, p. 198).

Terminology:—There is no native name, either English or Celtic. The usual names "cony" and "rabbit" are, as will be shown below, both of French origin.

"Rabbit" is pronounced also *rabbidge* (*Dial. Dict.*), *rabbert* (North Devon), *rabbut* (Berkshire and Devon), and *rappit* (Cheshire and Lancashire). Earlier forms are *rabbette* (15th and 16th centuries), *rabet* (15th to 17th centuries), *rabbet* (16th to 18th centuries), as in Pennant, Bingley, Jenyns, and Donovan), *rabbatte* (16th century), *rabytt* (17th century), *rabit* (18th century). The source appears to be the Walloon form *rabett*, still in common use at Liège, from Middle Dutch *robbe* = a "rabet" with the suffix *ett* (Skeat). Ultimately of French origin, it is borrowed by Gaelic writers and spelt in various ways as *rabaid*, *rabbaid*, or *rabbait*. Although frequent in combinations, "rabbit" is a comparatively modern word, not known *fide* the *N. E. Dict.* to have been in use before 1398, when it occurs in a passage in Trevisa: "Conynges bringeth forthe many rabettes." But Skeat informs me that in Grose's *Antiquarian Repository*, 1807, i., 78, there is a list of things provided for a feast in the eleventh year of Richard II., *i.e.* in 1387-88. Along with the poultry consumed are mentioned "six kiddes" and "viij dussen rabettes," and in the third course they had "rabetts rostad."

The above quotation indicates that "rabbit" was originally a diminutive applied to the young of the cony, itself an older word, as will be shown below. This fact is made clear from several sources. Thus in the *Promptorium Parvulorum*, written in 1440 (*Camden Soc. Public.*, t. ii., 1853, 421), a "rabet" is defined as a "yonge conye . . . *Cunicellus*." Again, in *The Boke of Nurture*, dating from about A.D. 1460, by John Russell (ed. Early Eng. Text Soc., 29), directions are given for carving the cony and also "rabettes," which are explained as "sowkers" (sucklers). In *The Boke of St Albans* (1486), the definition is further enlarged, and "a Bery (*i.e.*, burrow) of conyis" (*i.e.*, adults) is mentioned, as well as "A Nest of Rabettis" (*i.e.*, young); in fact, in the fifteenth century the two were so clearly distinguished as to form separate courses of the same feast (see below, p. 187). This use of the words had not died out in 1575, when we read that "The Conie . . . beareth hyr Rabettes xxx dayes, and then kindeleth" (*The Noble Arte of Venerie or Hunting*, 1575, ch. 63, 178).

"Cony" or "coney," various forms of which will be found in the *New English Dictionary*, is, as stated above, the older name, but is also comparatively modern. It occurs first in 1200, in the sense of the skin or fur of the animal (see *N. E. Dict.*); again in 1292 in the Anglo-Norman French of the lawyer Britton—"De veneysoun et de pessoun et des coniys"; and ten years later (1302), in English—"We shule flo the Conyng, ant make roste is loyne" (Political Songs in *Camden Soc. Public.*, 191), being a joke on the name of a Fleming called "Conyng." The word has not been traced farther back, though the animal was alluded to at earlier dates under the Latin name *cuniculus;* but there is no doubt that it originated in the old French *connil* or *counil* (a word cognate with the Provençal *conil*), of which the Norman plural was *coniz*, later *conis;* this gave an English plural, *conys*, *conies*, from which came a singular, *cony*, *conie.*

The forerunner of *cony*, the Greek κύνικλος, whence the Latin *cuniculus*, made its first appearance in literature in the "History" of Polybius (§ 12, 3, 10), written about 204 B.C. If Ælian (*De Natura Animalium*, xiii. 15), who lived in the third century of the Christian era, be correct, the word was imported from the Celto-Iberians, *i.e.*, the Basques. Strong (*Zoologist*, 1894, 401-6), would therefore connect it with the modern Basque word for a rabbit, *unchi*, which he suggests has probably undergone mutilation since Greeks and Romans borrowed it over two thousand years ago. But if so, the Romans must have soon forgotten the origin of the word, since Varro (*De Re Rustica*, iii., 12), and Pliny (*Historia Naturalis*, viii., 55) connected it with *cuneus* = a wedge, supposing it to have reference to the digging powers of the animal.

Many surnames and compound words are popularly connected with *cony*, but often in error. No genuine English name could have thus originated, because the first part would have to be a French word dating from about the 13th century. No name, therefore, derived from the word can be older than that period. On the other hand, many Irish names of places are genuinely thus derived, and must, therefore, be more recent than the Norman Conquest. They are usually easy to recognise, and may be found in Joyce's *Irish Names of Places;* but a few are difficult, such as *Kylenagoneeny* (*Coill-na-gcoinínidhe*) = wood of rabbits, Co. Limerick; and *Lisnagunnion* = fort of rabbits, Co. Monaghan.

Cony-garth or *coney-garth*, a rabbit-warren, from late Middle English *conyngerthe*, came undoubtedly, according to Skeat, by misdivision from *connynge*+*erthe*, as if from *cony*+*earth.* *Conyger* or *conigree;* *coney-grees* or *coney-greys* (as in Cheshire, *fide* Coward and Oldham); *coneygreeves* (also in Cheshire); and *cunnigreene*, with many other forms, being corruptions of the same type, came from the Old French *conniniere* or *coninyere* (adapted to *connin*), later also *conilliere*, from Low Latin *cunicularia*, being properly the feminine of an adjective *cunicularius* = pertaining to a rabbit (*Cent. Dict.*). All of these must be more recent than Domesday Book, which was finished about 1086, and in which warrens are not mentioned. "Cunicularia" first appear in the anonymous Latin book on English law cited as "Fleta," and supposed to have been written in 1290; and "conigers" in 1292, in Britton (see *N. E. Dict.*).

Many borrowed Celtic forms occur, as in Welsh *Cwning-gaer*, where the latter part of the word is adapted in form to *caer*=castle (*N. E. Dict.*). The Irish is *coinicéar*, occurring in many forms in all four provinces; the best known is *Cunnigar* or *Kinnegar;* the most corrupted are *Nicker* of Co. Limerick and *Nickeres* of Co. Tipperary (Joyce). As stated above, none of the above names are earlier than the Norman settlements (Westropp; Joyce, *in litt.*).

Riote or *ryote* is given by Harting (*The Rabbit*, 1898, 4) following Halliwell (*Dict. Arch. and Provincial Words*, 11th ed., 1889), as a third name for the animal, on the authority of a passage in "MS. Bodl. 546," one of the MSS. of *The Master of Game*, by Edward, second Duke of York (written 1406-1413). The passage has been modernised in Baillie-Grohman's edition of 1909, 74, from which I quote here in preference to the complete edition of 1904:[1]—"Of conies I do not speak, for no man hunteth them unless it be bishhunters (fur hunters) and they hunt them with ferrets and with long, small hayes (*i.e.*, nets). Those raches (*i.e.*, scenting hounds) that run to a coney at any time ought to be rated saying to them loud, 'Ware riot, ware,' for no other wild beast in England is called riot save the coney only." There is, however, no evidence that the word *riot* was ever applied definitely to the rabbit as a name, and the Master of Game himself uses only the word *cony* elsewhere in his work (*ed. cit.* 18), so that some other explanation must be found for the word *riote*. The expression "ware riot" may mean merely "beware of brawling," in accordance with the usual signification of 'riot' as given by Skeat. This is borne out by the fact that the cries of hounds in pursuit of an unusual quarry are different from their ordinary 'music,' and may be noisier or more riotous; and no animal is more likely to lead hounds to 'run riot' than a rabbit.

Local names (non-Celtic):—*Bun* of Northumberland, Warwick, Worcester, Yorkshire, Scotland, and Ireland, also used for the tail of a hare or rabbit, as "Poor maukin . . . Cocks her bun in rude defiance of his pow'r" (Davidson, *Seasons*, 1798, 272, in *Dial. Dict.*); *bunny* (or *bonny* of Devon), a child's name in quite general use; *burrowing hare* of MacGillivray; *clargyman*, often applied to black varieties, as in Cheshire (the fur of black conies was worn by the clergy, see *N. E. Dict.*), compare *parson*, a term widely in use, as in Somerset and Devon (*Dial. Dict.*); *grazier*, *i.e.*, a young one just going to feed on grass, used both in England and Ireland (Coward and Oldham; *Dial. Dict.*; Joyce);

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[1] The words are italicised by Baillie-Grohman, to signify that the matter was originally contributed by "Master of Game" himself, and not merely translated, like the greater part of the work, from the French of Gaston de Foix's *Livre de Chasse*.

hedgehog, a term applied to non-burrowing rabbits by dealers and fanciers (Blaine, *Encyclopædia of Rural Sports*, 1875, 883); *jack-rabbit*, a common name for a hare in North America, applied to half-grown specimens in North Lincolnshire (*Dial. Dict.*); *jack-sharp* of Lancashire (*Dial. Dict.*); *map* of Banff and Clydesdale (*Dial. Dict.*), which is also a name for a rabbit-call in Banff, Aberdeen, and Perth (*Dial. Dict.*); *mappy* (*Dial. Dict.*) of Northumberland, Galloway, Lothian, Fife, and Aberdeen, from the verb *map*=to nibble, compare *mapsie*=a young hare (*Dial. Dict.*); *parker*, a term apparently synonymous, or nearly so, with *hedgehog* (Blaine, *op. cit.*); *parson*, see *clargyman* above; *rump*, *i.e.*, a young one, of Hereford (*Dial. Dict.*); *scut*, also written *scutt* in Nottingham and Sussex, and *skut* in Kent, West Yorkshire, Northumberland, and Lakeland, a common word for the tail of a hare or rabbit in Great Britain and Ireland, also occasionally applied to the animal itself, compare "Rabbits flashed here and there with little white scuts twinkling through the gorse" (Phillpotts, *Prophets*, 1897, 159, in *Dial. Dict.*); hence *scutty* means short-tailed, and "to show the white rabbit scut" is the same as to "show the white feather" (*Dial. Dict.*); *sweetheart*, a tame rabbit (Blaine, *op. cit.*); *warrener*, a rabbit living in a warren (Blaine, *op. cit.*), cf. *parker*, above.

(Celtic):—There is no original name, but forms of *rabbit* or *cony* are used. Of the latter, the Irish version is *coinín;* the Scottish, *coinean* or *conning;* the Manx, *conning;* the Welsh, *cwning*, plural *cwninger;* the Cornish, *cynin.* Variants are numerous.

Hares and rabbits are said to *kindle* when they bring forth their young; compare:—

> "As the cony that you see dwell where she is kindled."
>
> —SHAKESPEARE, *As You Like It*, III., ii.

The word has several variants, as *kennel* of north country, *kinly* of West Somerset, *kinnle* of Durham and east and west Yorkshire, *kintle* of Durham (*Dial. Dict.*). It is also applied to cats, although this usage appears to be dying out; compare "A Kyndyll of yong Cattis" (*The Boke of St Albans*, 1486), and is evidently a word of some antiquity.

History:[1]—The Rabbit was not known to the Greeks of classical times, although Xenophon's description, in his *Cynegeticus*, of a certain small species of hare has sometimes been interpreted as referring to it.

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[1] The numerous references included in this section have been collected from a number of papers and works, all of which it would be impossible to mention. The following cannot be omitted:—(1) "The Rabbit (*Lepus cuniculus*) as known to the Ancients," by Houghton, *Ann. and Mag. Nat. Hist.*, March 1869, 279-183; (2) A long paper on the same subject by Brandt, *Bull. de l'Acad. Imp. des Sci. de St Petersbourg*, ix. livre 4, 1875, 459-90; (3) *The Wanderings of Plants and Animals*, by Hehn, English ed. of Stallybrass, 1885, 343-45, 489-91; (4) *Gleanings from the Natural History of the Ancients*, by Watkins, 1896, 161-162; and (5) *Die Antike Tierwelt*, by Keller, 1909.

Aristotle (*Historia Animalium*, ed. Thompson, 1910, vi. 33, 580^a, 5) makes the curious statement concerning hares that "the young are born blind, as is the case with the greater part of the fissipedes or toed animals"; but there can be no doubt that this was an error and not an allusion to rabbits, the earliest known direct reference to which is that of Polybius, as quoted above (p. 178). Writing in Greek of Corsica in 204 B.C., he stated that, although there were no hares there, there were other animals which he called κύνικλοι (kunikloi), resembling small hares, but greatly different when examined in the hand, and burrowers in the ground. Some earlier allusions have not been substantiated. Thus Darwin (*Variation of Animals and Plants under Domestication*, 1868, I, 103) remarks that rabbits are mentioned in a translation of one of the books of the Chinese philosopher Confucius, who was born in 550 B.C. I have been unable to find the passage, but several authorities whom I have consulted are unanimous that it refers not to the Rabbit, but to some species of hare. De Mortillet also (*Promenade au Musée de Saint-Germain*, in *Matériaux pour l'Histoire de l'Homme*, Ann. 4, 1868, 10-12, 407) states that some caged rabbits ("Des lapins en cage") form part of an Egyptian bas-relief of the fifth dynasty. I have consulted Wallis Budge and others in regard to these, and there can be no doubt that the identification is due to confusion with hares.

Cuniculus next appears in the works of Roman writers of about the first century B.C. Posidonius of Apamæa, historian and philosopher of the beginning of that century, mentioned it in his *History* (as quoted by Athenæus, *Deiphnosophistæ*, Bk. ix.); the poet Catullus (*Carmina*, xxxvii., 18) sang of Spain as a country full of rabbits and rabbit holes:—"Tu . . . cuniculosæ Celtiberiæ fili egnati;" and Martial (*Epigrammata*, xiii., 60) aptly described it in the lines "Gaudet in effossis habitare cuniculus antris." Varro (*op. cit. supra*, p. 178), who flourished between 116 and 27 B.C., states that it was found in Spain, and discusses the derivation of its name. The geographer Strabo (Bohn Library, I, 217), who was born about 63 B.C., notices (*Geographica*, Bk. iii., c. 2, § 6; Hamilton and Falconer's translation) its abundance in the Balearic Islands,[1] as well as in almost the whole of Iberia (Spain); it extended to Marseilles, "infesting likewise the islands" and destroying both seeds and trees, the latter by gnawing their roots. He states that the inhabitants of the Balearics once despatched an embassy to the

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[1]

Τῶν	δ' ὀλεθρίων	Θηρίων	σπάνις	πλὴν	τῶν	γεωρύχων
Of the	destructive	animals	a scarcity	except of	the	earth-burrowing

λαγιδέων	[lagiděōn]	οὓς	ἔνιοι	λεβηρίδας	[lěbēridas]	προσαγορεούσι.
little-hares		which	some	leberides		call-by-name.

According to Liddell and Scott's *Lexicon*, λεβηρίς may have been a Massiliote word for "rabbit."

Romans to beg for a new land to dwell in, as they were quite driven out of their country by these animals, being no longer able to stand against the vast multitudes. Amongst the many methods of hunting these little hares was that by γαλᾶς ἀγρίας from Africa trained for the purpose, where the Greek words are usually translated "wild cats." The meaning of γαλᾶς is, however, uncertain; the passage looks like an early description of ferrets, but there is the difficulty that the Polecat or wild form of Ferret is unknown in Africa. Pliny (about A.D. 23-79) added that the deputation from the Balearic Islands was sent to the Emperor Augustus to demand a military force, apparently to assist in destroying the rabbits, and much the same story was repeated by Ælian (*op. cit. supra*, p. 178), the exact date of whose writings is uncertain.

The animal was evidently regarded by the Romans as peculiarly characteristic of Spain. It appears on Romano-Spanish coins of Hadrian (who was emperor from 117 to 138 A.D.), examples of which are in the British Museum; one is figured by Cohen, *Monnaies Frappées sous l'Empire Romain*, 2nd ed., vol. ii., 175, No. 821. There is also a marble group, again of the second century, in the British Museum (No. 1764), supposed to personify the Province of Spain, and which includes a boy, a woman, and a rabbit in a basket. This has been figured and described by Michelle Jatta, *Le Rappresentanze Figurate Delle Provincie Romaine*, 1908, fig. 10, 41.

The Jews also, who are said to have known of Spain and its products from the time of Solomon, are thought by some authorities to have given the country its modern name with reference to its rabbits. At least the classical name for the country, Hispania, now España or Spain, is traced back by Bochart to the Shemitic *tsâphân* = "the hider" (Smith's *Dict. of the Bible*, 1893, iii., 1364, art. Spain), a name which the Jews are believed to have applied to the rabbit in Spain. This word must have been originally used in connection with some other animal, almost certainly the "cony" of the Bible, which was not a rodent, but a "hyrax," or "rock badger" (*Procavia* of Storr, 1780, antedating *Hyrax* of Hermann, 1783), since true rabbits were unknown in Palestine. This fact makes Bochart's derivation extremely doubtful, but does not alter the fact that Spain was famous for its rabbits.

The older name for Spain, Tarshish = Tartessus of the Greeks, was used by Herodotus (*History*, iv., c. 192, B.C. 500, ed. Rawlinson, iii., 142)[1] in connection with the aforesaid word γαλᾶι, which has here been translated "weasels," and may again mean "ferrets," in which case this may represent the earliest indirect reference to rabbits, since ferrets

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[1]

Εἰσί	δὲ καὶ	γαλαῖ	ἐν	τῷ	σιλφίῳ	γινόμεναι	τῇσι	Ταρτησσίῃσι	ὁμοιόταται.
There are	also	weasels	in	the	Silphium	existing [found]	to-the	Tarteesian	most-like.

could only have been used for catching these rodents, and it is known that their use dates back to very early times.

It was not long before the value of rabbits for food so appealed to the Romans that they began to import them to Italy, where they appear to have gained a footing at least by A.D. 230, about which time they were observed numerously by Athenæus on an island (evidently Nisida or Nisita), near Dichæarchia or Puteoli, now Pozzuoli, itself near Naples (*Deiphnosophistæ*, Bk. ix., c. 63, Yonge's translation in Bohn Library, ii., 631-632). In A.D. 303 the maximum prices for rabbits and hares were fixed by the edict of Diocletian at 40 and 150 denarii respectively. The former were considered a great delicacy, and in later times it was the fashion to eat the embryos, under the name of "laurices" ("laurex" being apparently a Balearic word signifying a fœtal rabbit) during times of fast (see Gregory of Tours, quoted below).

From the above quotations it is certain that the Rabbit, as first known to history, was an abundant animal in the Iberian Peninsula, and that its range extended to the south of France as far as Marseilles, with Corsica and the Balearic Islands. Thence it was introduced to Italy before A.D. 230. That it was indigenous to the Iberian Peninsula is shown by many other facts, and it is not mentioned in early historical times as inhabiting any other region, but the following facts suggest that it may have also existed in central France, although without the knowledge of early writers.

Since there are no names for the animal in any central European language other than those derived from the Latin *cuniculus*, it cannot have been indigenous outside the above limits. But there is no information either as to exactly when or how it spread north from its original habitat; nor as to whether its coming was natural or artificial, and, if the latter, whether it was first introduced as a wild or tame animal. Reinach (*Antiquités Nationales—Description raisonnée du Musée de St Germain*, ii., 301) has reproduced some third-century drawings of rabbits from central and southern France; and Gregory of Tours (A D. 540-594; see *Historiæ Francorum*, lib. v., iv.), writing of his contemporary Roccolenus, records the fact that in times of fasting he frequently ate unborn rabbits at or near Poitiers. On the other hand, Petrus Crescentius, an inhabitant of Bologna, Italy, about A.D. 1265-1321, who clearly defined the geographical distribution of the animal in his days, stating (*Opus ruralium Commodorum*, lib. ix., c. 80) that rabbits inhabited Spain, Provence, and the neighbouring parts of Lombardy, omitted all mention of central France. This is remarkable, since these rodents must also have been known at least as far north as central France before the thirteenth century; as apart from the fact that they had been already introduced into Britain (see below, p. 186), they are familiarly described in the northern or central French original of Chaucer's *Romaunt of the Rose* (see p. 196). The inconsistency might be explained if it could be shown that Gregory's rabbits as well as the first introductions to Britain, were of a tame or semi-tame stock, which later escaped and became wild. Rabbits must have been domesticated at a very early date, and, it might have been expected, by the Spaniards, and, following them, by the Romans; but it is noteworthy that domestic races are not mentioned by any of the earlier writers. It is clear from the German naturalist Gesner's account (1551) that, in the wild state at least, they were unknown in Switzerland and south Germany (Zurich, Basle, Strassburg) at that date. He is compelled to restrict himself to a description of their varieties in colour, and to note their abundance ("copiosissimi sunt") in hilly places and rocky mountains in Spain, which details he obtained by letter from a friend (p. 397); and he adds a note on their great numbers in England (p. 398), and comments on the fact that in that country some people lived entirely by keeping rabbits.

At about the same date they were so abundant in central France that du Fouilloux, who wrote *La Venerie* at Poitiers in 1561, declared that gentlemen would not spend much time in their pursuit, but left that amusement to their servants.

The animal is commonly supposed to have been introduced into **Britain** by the Romans, but this was certainly not the case, since, as shown above, it had no native name in any part of the three kingdoms until the Normans came over and named it. Another point of importance in this connection, and supporting a French as against a Roman introduction, is the fact that the British Rabbit belongs to the typical northern subspecies *O. cuniculus cuniculus*, and not to the smaller Mediterranean form. The first advocate of a Roman introduction appears to have been John Whitaker (*The History of Manchester;* London, 1771, I., x., 344), but he cites no facts in support of it, and he may have been misled by a supposed Latin origin of the name "cony," whereas, in fact, as has been shown above, this word, as well as the more modern term "rabbit," came to Britain from the French.

There are no pre-Norman British allusions to the animal, and it does not appear on coins as in Spain. Had it been known in Britain in his time, Julius Cæsar would no doubt have mentioned it with the hare, the hen, and the goose, all three of which he stated to have been foods unlawful to the ancient Britains (*De Bello Gallico*, v., 12). As noticed above, warrens are not named in Domesday Book, and could not, therefore, have been known in the eleventh century; and rabbits were also omitted by King John when, about May 1199, as Earl of Moreton (*i.e.*, Mortain in Normandy), he granted immunities to his tenants outside the regard of Dartmoor Forest, Devon, to take hares and other animals (see Rowe's *Perambulation of Dartmoor*, 1848, 263); and they do not appear in other documents of the period, although specifying hares, pheasants, and partridges. The above quotations suggest absence, or at least scarcity. Between A.D. 1183-1186, however, "cuniculi" were casually named by Giraldus Cambrensis when writing in Latin of the Irish Hare (see below, under *Irish Hare*, where the whole passage is transcribed); and as shown above on p. 177, the fur or skin was mentioned in 1200 (and Sir James Murray informs me that the passage may well date from 1175). Both references indicate that rabbits were then well known, although not necessarily members of the British fauna. The first undoubted record of their occurrence in Britain has been supplied by Hinton (MS.), who has recently determined the bones of individuals used for food from the midden of Rayleigh Castle, Essex, the occupation of which commenced in the eleventh and ended about the beginning of the thirteenth century. That they must have become plentiful, at any rate locally, by, at latest, the second half of the latter century, is shown by an inquisition of Lundy Island made in 1274 (Steinman, *Collectanea Topographica*, iv., 1837, 316-17), wherein the annual taking is estimated at two thousand, being worth £5, 10s., and the estimate is said to be at 5s. 6d. "each hundred skins, because the flesh is not sold," although it was considered as of some value to the keepers of the island. In 1272 the capture of conies with ferrets at Waleton is mentioned (Rogers, *History of Agriculture and Prices in England*, ii., 576); and in 1282, at Rhuddlan Castle, Flint, Richard-le-Forester received 3s. 6d. for catching these animals for the king's use and for keeping the king's ferrets (*The Antiquary*, August 1911, 302). Subsequent allusions are more frequent; in 1290 rabbit-warrens (*cunicularia*) appear in Fleta (see above, p. 178), and the skins were priced at Oxford several times between 1310 and 1313 at rates varying from ten to the shilling to twenty-six for 1s. 11d. (Rogers, *op. cit.*, ii. 537). The animal soon became an important item at feasts, and in Henry's *History of Great Britain* (ed. 1., 1781, vol. iv., App. iii.), being a translation from *Historiæ Anglicanæ Scriptores*, by Gulielmus Thom. Cantuariensis, 1652 (Chronica, 2010), the following list of meat and poultry is recorded as having been paid for at the installation feast of Ralph de Borne, Abbot of St Austin's Abbey, Canterbury, in 1309:—

De porcis C. pretii	xvj. *li.*
De multonibus CC. pretii	xxx. *li.*
De aucis M. pretii	xvj. *li.*
De caponibus et gallinis D. pretii	vj. *li.* v. *s.*
De pulonibus iiij. C. lxjjj. pretii	lxxiiij. *s.*
De porcellis CC. pretii	C. *s.*
De Cignis xxxiiij. pretii	vij. *li.*
De cuniculis vj. C. pretii	xv. *li.*

Line 1 = porkers; 2 = wethers; 3 = geese; 4 = capons and fowls; 5 = chickens; 6 = apparently sucking pigs; 7 = swans; 8 = rabbits.

The rabbits, therefore, cost 6d. each, equal to about 6s. 6d. of our own time.

This price, which was identical with that of a porcellus (? = sucking pig) in the same list, presents a valuable indication of the scarcity of rabbits at the period, and suggests that they were still something out of the common. On the other hand, it seems to have been exceptionally high even for the time, for the maximum encountered by Rogers, who (*op. cit.*) made a special study of the question, was 5d. each in 1270, and thereafter, according to his researches, rabbits became cheaper until, in 1365,[1] they were entered in certain lists at 2½d. (*op. cit.*, i., 33 and 165), and in 1413-1414 at 2d. (*op. cit.*, iii., 130). Rogers considered (i., 340) that in the thirteenth and fourteenth centuries rabbits were so dear as to suggest, either that they were at that time confined to particular localities, from which they subsequently spread over the whole country (a view which seems to be countenanced by the fact that the value did not increase in the later part of the period); or, as seems hardly credible, that they were rigorously and effectually protected in the interests of the great landowners. Not only were the prices at first, relatively to those charged for other provisions, very high, but they afterwards declined, which is difficult to understand, "except on the hypothesis that rabbits were scarce, had been but lately introduced into the country, and were confined to very narrow limits or to particular properties" (p. 341).

Conies are often mentioned in the fourteenth century, as, for instance, by the poet Chaucer (1340-1400), "The litel conyes to hir playe gan hie" (*Assembly of Foules*, ed. Bell, iv., 1963); this line, however, as Skeat has most kindly informed me, was taken direct by Chaucer from an older French poem, *Roman de la Rose* (see below, p. 196), and must, therefore, be ruled out as evidence. In 1377 the animals were an article of commerce in Berwickshire (Tate, *Proc. Berwickshire Nat. Club*, 1863-1868, 441, 1869), and in 1389 conynges, with their warrens and connigries, and ferrets make their first appearance in the Statute Book (13 Richard II., stat. i., c. 13). But some records still suggest scarcity. At a banquet given to Richard II. by the Bishop of Durham in 1386 four hundred conies were served; but in a Determination Feast in 1395 twenty couples were bought at 6d. or 8d. the couple, which seem to have been procured from Bushey, Hertfordshire, whence they were carried to Oxford at a charge of ½d. each. This would hardly have been necessary had the animals not been scarce, and the fact supports Rogers's belief, as quoted above, that they were still unevenly distributed over the country, having been introduced before the thirteenth century.

In the early years of the fifteenth century the animals were mentioned casually by Edward, second Duke of York (1406-1413, see above, p. 179, under Terminology); and in many of the great feasts of the period, from the Coronation of Henry IV. in 1399, to the stalling of the Archbishop of Canterbury in 1443 (see *Harl. MSS.*, 279, written about A.D. 1430-1440; and 4016, about A.D. 1450), both "conyngges" and "rabettys" (or similar forms), have a place in the bill of fare. They were clearly distinguished, and often appear as separate courses of the same feast, and conies at least were evidently so important that a special expression was used for carving them, carvers being instructed to "Unlace that cony" (*Babees Book*, Early Eng. Text Soc., 265). By 1465 they may well have become as abundant as they are now, since no less than four thousand "conyes" appear on the bill of fare at the grand feast given at the installation of "George Nevill, Archbishop of York, and Chancelour of Englande" (Leland, *Collectanea*, vol. vi., 2, etc.). In 1486 rabbits and conies are mentioned in *The Boke of St Albans.*

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[1] In Boase's *Registrum Collegii Exoniensis*, 1894, xl., it is stated that in Lent 1361, at a feast of St Thomas the Martyr, 8d. was paid "for rabbits," but unfortunately no account is given of the number obtained for this sum.

In the first half of the sixteenth century, one dozen "rabbet ronners" were sold for 2s. (*Household Ord.*, 333), and in 1530 the price was 5d. a couple in Yorkshire (Clarke and Roebuck). It seems, however, to have risen again soon afterwards, in agreement with that of other commodities, being 4d. each in 1550 (Rogers, *op. cit.*, iii., 191); and Cocks has sent me an extract from the diary of his collateral ancestor, Thomas Cocks of Canterbury, dated 9th November 1610, "for a rabett 9d." Before that date the fame of their numbers in this country must have been widespread, for Gesner (1551), describes their immense abundance (*copia ingens cuniculorum*) in the same paragraph as that in which he treats of Spanish rabbits; and he comments on the fact that, although restricted in Spain to hilly and rocky places, in England they delighted in woods and groves, in fact in open country.

Both rabbits and conies are more than once mentioned by Shakespeare, who died in 1616:—*E.g.*, "parsley to stuff a rabbit" (*Taming of the Shrew*, IV., iv.); "Like a rabbit on a spit" (*Love's Labour's Lost*, III., i.); and "earth-delving conies" (*Venus and Adonis*, but see also above, p. 180); and early in the seventeenth century they had attained a position of value and profit, as well expressed by Reyce in 1618 (*The Breviary of Suffolk*, ed. Hervey, 1902, 35):—"Of the harmlesse Conies, which do delight naturally to make their aboad here, . . . their great increase, with rich profitt for all good house keepers, hath made every one of any reckoning to prepare fitt harbour for them, with great welcome and entertainment, from whence it proceeds that there are so many warrens here in every place, which do furnish the next marketts, and are carried to London with noe little reckoning, from whence it is that there is none who deeme their houses well seated, who have nott to the same belonging a comon wealth of Conies, neither can hee bee deemed a good house keeper that hath not plenty of these at all times to furnish his table."

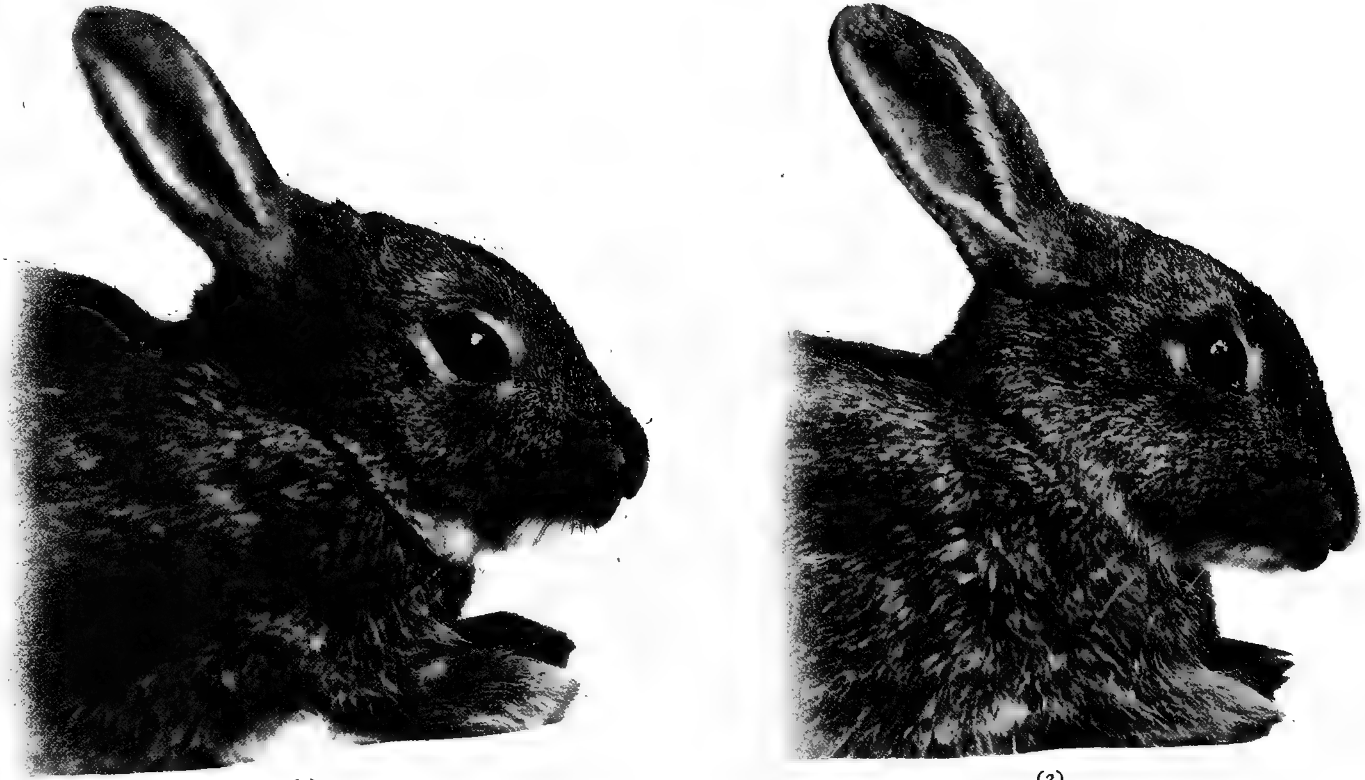
There is no need to trace the animal's history further, since in its double capacity of provider of food and fur it remained in high value until recent years. At the end of the eighteenth century, Marshall (*Rural Economy of Yorkshire*, ed. 2, 1796, vol. ii., 226-228) calculated the value of the skin in proportion to that of the carcase as higher than that of a sheep or ox. But of recent years so many carcases and skins have been imported into Britain, especially from Australia, that the value has greatly declined, and it is doubtful if rabbits are any longer a source of profit to landowners, unless, perhaps, under somewhat exceptional circumstances and management.

The Rabbit, as shown by the passages quoted above on pages 179 and 184 from *The Master of Game* and from du Fouilloux, was never accounted of any honour or value by British or northern French sportsmen, nor was it deemed worthy of their attention until the days of fire-arms; and, as shown above (p. 187), it is only mentioned incidentally in *The Master of Game.* This is worth notice, because the great French sportsman, Gaston de Foix, of whose masterpiece, *Livre de Chasse* (commenced 1st May 1387), the English work by "Master of Game" is mainly a translation, admits it to a place in the list of fourteen animals, which he describes for the benefit of sportsmen.

In **Scotland**, according to Alston, the Rabbit was little known before the beginning of the nineteenth century, even in many lowland localities where it now abounds; up to that date it appears to have been confined mainly to certain islands and to the coastal sand-dunes of the mainland. But William Evans has shown that it was abundant in portions of the Edinburgh district at least as far back as the early part of the sixteenth century; and he suggests that it was introduced by the inmates of the various monasteries. Its numbers probably remained nearly stationary, or, more probably, its range was more or less restricted, until the early part of the nineteenth century, after which it began to occupy new country, and underwent a rapid increase in numbers. Similarly in Aberdeen, according to Sim, it is mentioned in documents as evidently common at least so far back as the year 1424; and the same authority states that in the *Exchequer Rolls* a duty of 1s. a hundred was charged on cony skins during the fourteenth century; but the latter record is not altogether trustworthy, as in enactments concerning duties items are sometimes copied from foreign documents.

There is evidence that in many other parts of Scotland, especially in the Highlands, the animal did not make its appearance until as the result of comparatively recent introductions; and in the north, as in Sutherland, many perish in severe winters (Harvie-Brown

PLATE XII.



(1)

(2)

Heads of (1) Male and (2) Female Rabbit, to show sexual differences. Photographed by G. D. Croker, Waterford, from specimens obtained at Kilmanock, Co. Wexford, and arranged by M. Parle, gamekeeper.

and Buckley). In Caithness it is said to have been plentiful in 1793, but unknown in 1743 (Bruce). Of late years it has spread widely, until it is now as abundant and ubiquitous in Scotland, excepting only the highest hill-tops and the wet flow-lands, as in any other part of the three kingdoms.

The history of the Rabbit in **Ireland** is similar to that for Great Britain. The word "lepusculos" occurs in a list of Irish animals given by the ecclesiastic Augustin, who wrote about A.D. 655 (*Proc. Roy. Irish Acad.*, vii., 518, 1862), but this must evidently be interpreted as referring to the Irish Hare. Conies are found in a longer list contained in the Irish poem printed by Wilde (*Proc. cit.*, 188-189)—"Da choinin a Dhúmha duinn," *i.e.*, two conies from Dumho Duinn—but this poem, although supposed by Ball (*Proc. cit.*, ii., 541) to be older than A.D. 1000, really dates only, as Kuno Meyer informs me, from about the thirteenth or fourteenth century. The ancient Irish, who were great hunters, and wrote at length of the various beasts of chase, including hares, never mention rabbits, as it is certain they would have done had they known them. The oldest undoubted British reference to them of which I am aware is that of Giraldus Cambrensis, who, as stated above (p. 185), casually alluded to "cuniculi" in 1183-1186, but without definitely including them in the Irish Fauna. The animal's name begins to appear in documents at about the same time as in England, so that the conclusion is that its introduction to Ireland also must be attributed to the Normans. With their warrens, conies are casually noticed in the time of Edward I., viz., between 1274 and 1307 (see Westropp, *Proc. cit.*, xxv., c., 8th March 1905, 343); and in 1282 twenty skins from Balisax (now Ballysax), Co. Kildare, were priced at 1s. 4d. (Rogers, *op. cit.*, ii., 567); and one hundred "great coneys" from the same locality in 1287 at 13s. 4d. (*id.*, ii., 558-559). In 1324 the profits of hunting the "cunicularium" at Rosslare, Co. Wexford, formed a portion of the return of the lands of Aymer de Valence, an item of information for which I am indebted to G. H. Orpen. In the fourteenth and fifteenth centuries the skins had become a regular article of export with those of other mammals, being included in *The Libel of English Policy* (Political Poems and Songs; Rolls Series, ii., 186), written about 1430: "Felles of kydde and conies grete plenté." Many later travellers in Ireland record having seen the animals in different parts of the country, as a matter of course. Fynes Moryson, in his "Description of Ireland," about 1600 (Falkiner's reprint, in *Illustrations of Irish History and Topography*, 1904, 223), wrote of "great plenty of . . . . conies"; Sir William Brereton saw them on the banks of the river Slaney in the manor of Ollort (now Oulart), Ferns, Co. Wexford, on 16th July 1635 (Falkiner, *op. cit.*, 390); and for another notice of them, see below, p. 196. At the Park, near Wexford, on a Mr Hardy's land, rented from William

Synode (now Synot), the last writer noticed "abundance of rabbits, whereof here there are too many, so as they pester the ground." Later, Arthur Young, whose well-known "Tour in Ireland" took place during the years 1776-1779, noted the price of them in many parts of the country.

Distribution :—For the present distribution of the Rabbit, see that of its genus (above, p. 173). It has, however, been artificially introduced by man into so many localities all over the world that it is difficult to exactly define the boundaries of the areas where it is indigenous. In many cases it multiplies so exceedingly after introduction that, as in Australia, it has become a national plague. It will not, however, thrive in the Arctic regions, nor in the north of Europe generally, not even in the south of Norway, probably in consequence of the depth of snow that covers the ground in winter. Thus, as Winge informs me, although sometimes introduced, it has never become established in Denmark, and the exact degree of north latitude at which it will exist naturally in continental Europe has not been defined. It may, however, be successfully introduced on islands, in regions where it could not be established on the adjacent mainland, and this is characteristic of it everywhere throughout its range.

It is abundant in the Azores, Madeira, and the Salvage Islands, the last of which lie between the Canaries and Madeira, and has often been considered indigenous. But, since there is evidence that the early Portuguese navigators carried live rabbits on board ship, and that they turned them down at Porto Santo, a small island near Madeira, in 1418 or 1419 (see Darwin, *Variation of Animals and Plants under Domestication*, 1868, i., 112), it is probable that the stock on the other islands had a similar origin. Darwin was surprised to find that the Porto Santo rabbits possessed characters sufficient, had he not believed them to have originated since 1420, to "have ranked them as a distinct species." But this is explained by the fact that they belong to the small southern subspecies, *O. c. huxleyi* (Haeckel).

It is certainly not indigenous to Africa. Lataste did not meet with it on the mainland of Tunis, but found it abundant on islands off the coast; he also reported it as absent from the south of Algeria and the Sahara. Cabrera has obligingly informed me that in his opinion it is not a native of Morocco. It has been observed neither in the Riff, nor on the coast about Mogador and southwards, nor in the country between Mogador and Marrakesh. Although it certainly exists in the Chafarina Islands, it owes its presence there to introduction by the Spaniards.

Whatever be the origin of the **British** stock of rabbits, they are now probably the most vigorous, prolific, and abundant mammal in the islands, exclusive of the Brown Rat, the (true) mice, and the Common

Shrew. And this statement must not be taken to imply any inferiority. When the greater size of the Rabbit and its absolute defencelessness are taken into consideration, it is probable that it is, at least relatively speaking, more successful. Seven thousand have been killed by a single party in the course of one day's shooting (Millais). Simpson (*op. cit. infra*), a prominent breeder of wild ones, has put the number that can, given skilful management, be carried continuously on an acre of land as about one hundred; and a single London furrier is said to have accumulated ten tons weight of the tails alone in a single season (Patterson, *Eastern Norfolk*, 318). On this account it well deserves the title given to it by Poland, as "the great fur-producing animal of the kingdom," and foreigners travelling through Britain notice its abundance as one of the characteristic features of the fauna, a feature which appears to have been already evident in the sixteenth century (see Gesner's remarks quoted above on pp. 184 and 187).

The **fur** is used chiefly for felting, or hats; and is also dyed or clipped, and sold in imitation of the pelts of other more valuable animals, such as fur seal. Its cheapness makes its use almost universal, but it has little durability (see Poland, 278-289).

Although it thrives best on dry but rich pastures, the Rabbit may be expected wherever a blade of grass can grow; and from Cornwall to Caithness it holds its own in the face of the most relentless persecution, at the hands not only of man but of all stronger animals. It plants its colonies on almost inaccessible turfy ledges on the sides of sea cliffs and precipices. It ekes out a living even on poor lands; and soon reduces them to such a condition that larger grazing beasts would starve. Then, when overcrowding results in an epidemic, it dies away to scarcity, but a remnant is always left to reappear with renewed vigour and fertility until the former abundance is regained. If it objects to anything it is to cold and wet, but the objection is only relative, since it abounds in the continuous heavy rains of the Mull winters, and its mortality in that island is said to be far less than that of sheep (Simpson, *The Wild Rabbit in a New Aspect*, 1908, 22-23). Although checked by hard weather and heavy snowfalls, a few ascend to the cairns on the summits of the highest mountains even of Scotland; and in summer numbers thrive mightily on low-lying marshes, salt or fresh, entirely reckless of the disaster which usually overtakes them in winter. It loves cultivated fields and sheltered woodlands, where it grows fat and heavy on luxurious diet. But, albeit leaner and lighter in such a situation, it finds the barren windswept sand-dunes, perhaps because of their good drainage, a satisfactory habitat; and manages to maintain a thick population on some tiny stack or islet, where it contends with puffins and shearwaters for the possession of the burrows.

There is hardly an islet on which it is not established, having been in all cases where information is available, introduced. So universally is this the case that it seems hardly necessary to give details. It is present, generally in abundance, in the Farn and Holy Islands, the Channel Islands, Wight, Lundy, Bardsey, Anglesey, the Skerries near Holyhead (Pennant), Man (plentiful from at least 1658, Kermode); in probably all the Clyde islands, as Ailsa Craig, Little Cumbrae (at least from 1453), Great Cumbrae (previous to 1612, Boyd Watt), Arran (Pennant, Alston), Bute (W. Evans, *in lit.*), and other smaller islands (Boyd Watt); the Inner Hebrides, as Islay (Harvie-Brown and Buckley), Jura, Colonsay (Pennant, Alston), Iona (Harvie-Brown and Buckley), Mull (Alston), Tiree (Harvie-Brown and Buckley), Coll (Millais), Canna (Millais), and Skye (Macpherson); Handa and Rabbit Island (Kyle of Tongue), Sutherland (Harvie-Brown and Buckley); as well as the east coast islands in the Firth of Forth, including the Isle of May (W. Evans), and the Bass Rock (Millais). Although absent from St Kilda, it has been introduced into many of the Outer Hebrides, in particular Barray, Vatersay, South Uist, North Uist, Harris and Lewis (Harvie-Brown and Buckley). It was at an early date introduced in the Orkneys, and soon became so numerous that 36,000 skins were said to have been exported in 1795 (Alston). It is found on Fair Island (Kinnear).

According to Buckley and Evans, rabbits were plentiful in Shetland in 1750, and their occurrence there had been recorded so far back as 1700. They are now found more or less numerously throughout most of the larger islands from Unst to Dunrossness, but the above-named authors know of only one warren, that of Quendale, where the animals are really abundant. They are found on Fetlar, have been exterminated on Oxna, in Scalloway Bay, but are plentiful in Foula.

They are absent from the Faroes, or were so at the time of Feilden's last visit about 1890.

Many of the small islets off Ireland harbour colonies of rabbits. There may be mentioned Inistrahull, Co. Donegal (*Irish Naturalist*, 1897, 68); Lambay, Co. Dublin, where they were noticed by Rutty (*Nat. Hist. Co. of Dublin*, 1772, 274), and were so abundant in 1907 that 24,000 were killed in two years (Baring, *Irish Naturalist*, 1907, 22); the Saltees and Keeraghs, Co. Wexford (Barrett-Hamilton, *Irish Naturalist*, 1894, 68); the North Blasket, Western Island and Inishnabro, Co. Kerry (Andrews, *Dublin Nat. Hist. Review*, ii., 1855, 94). The ancient fort of Dun Ængus in Arran is practically a great warren (*fide* H. H. Brindley, 1888); and the animals are found also on Inishbofin; Inishturk; Caher (Browne, *Proc. Roy. Irish Acad.*, December 1898); and Clare Islands, in the latter case having been recently introduced (Westropp, *Proc. cit.*, "Clare Island Survey," December 1911, pt. 2, 34). A complete list is a desideratum.

Distribution in time:—Bones identified by their finders as those of the Rabbit, have been found in numbers of caves and in other deposits, chiefly in Great Britain, but also in Ireland. In most cases the remains were associated with others belonging to undoubtedly pleistocene species, but the Rabbit being a burrowing animal, fond of investigating cemeteries, its bones are usually open to the strong suspicion of being of recent origin, especially as their appearance is frequently fresh. This is the case with the bones found at Ightham and Longcliffe. Those found in the Kesh caves of Co. Sligo are certainly recent (Scharff, *Trans. Roy. Irish Acad.*, xxxii., B., iv., 200, September 1903), and are absent from the earlier strata. In a few instances, however, as at Kent's Cavern, the remains appear to be in the same state of preservation as those of undoubtedly early pleistocene mammals (Sanford, *Quart. Journ. Geol. Soc.*, London, xxvi., 1870, 138), and have been accepted as their contemporaries. Nine also of those found in the late pleistocene caves of Co. Clare are stated to have presented unmistakable signs of "antiquity" (Scharff, *Trans. cit.*, xxxiii., B., 1, 39, February 1906), and to have belonged to an animal having shorter fore-limbs than the modern Rabbit. But it is so difficult to tell the antiquity or age of individuals of this burrowing rodent, that it were well to regard with suspicion results based solely on appearance or length of bones. It may, however, be regarded as certain that a rabbit, closely resembling and not hitherto distinguished from *O. cuniculus*, was a member of the Early English pleistocene fauna; it was also present in that of central and western continental Europe, where it is traceable back to an ancestor, *Lepus lacosti* of Pomel (*Catalogue Méthodique*, 1853, 44) in the upper pliocene of France. It died out, and became, as shown above, restricted to a quite small tract in south-western Europe, and did not again appear in its pleistocene haunts until a comparatively recent date. The above view was formed by Rolleston (*Sci. Papers and Addresses*, i., 335-336). Since then Forsyth Major, while preparing his still unpublished catalogue of fossil rodents in the British Museum, and more recently Hinton also (*in lit.*), have arrived at the same conclusion.

The disappearance of the Rabbit is believed to have been caused by the cold (which means, probably, the snow) of the Glacial Period. Its return to Britain must undoubtedly have been due to introduction by man, but it is possible, since present conditions are so favourable to its existence, that it made its way north to portions of central Europe unaided. The increase of its numbers and extension of its geographical range may have been due to the spread of tillage and the reduction of wild forested districts, helped by the destruction of carnivorous beasts and birds. These factors, especially the latter, must certainly have accounted in no inconsiderable measure for its recent increase in Scotland. A northern extension of the range of the cottontails of

North America has taken place under somewhat similar conditions (Nelson, *North Amer. Fauna*, No. 29, 1909, 21).

In the present state of knowledge, the ultimate **origin** of the Rabbit is lost in obscurity. All that can be said is that its nearest modern relatives appear to be the cottontails[1] of North and South America; but these, as shown above on p. 173, present a puzzling mixture of characters which are difficult to interpret. If the resemblance be not, as in the case of the water-shrews of Europe and North America,[2] merely due to convergence, then the Siwálik deposits of India may be looked to for light by furnishing an extinct connecting link between these two genera of the family inhabiting the Old and New Worlds. At present such light is not forthcoming, since only one bone of a hare or rabbit is known from these deposits, and that one, as Lydekker informs me, is too fragmentary for satisfactory determination of its affinities. For an African origin of the Rabbit, there is no evidence, which fact seems to rule out a third suggestion, somewhat tentatively advanced by Scharff, namely, that the original connection between the Rabbit and the cottontails was by some now submerged southern or equatorial continent bridging the Atlantic.[3] The subject is discussed in connection with other mammals in the general Introduction.

Droppings:—These are of the typical leporine type, as described above on page 166. Their comparatively small diameter, measuring only about 9 to 11 mm., distinguishes them from those of the hares, in which the diameter reaches about 16 to 19 mm., as well as from those of goats, which are larger and not circular; the latter, when fresh, are usually attached to each other in a kind of string. Those of sheep, although also larger, are somewhat similar, but are very dark in colour, and do not show traces of herbage when dry. Rabbit droppings are often deposited in a conspicuous manner on bare spaces such as the surfaces of tree-stumps, or even on dry cow-dung. Their quantity at any one spot is, of course, much less than in the case of larger animals, such as sheep and goats, having droppings of similar character.

Description:—The general form and appearance, the skull and teeth, of the Wild Rabbit are typical of its genus. It resembles a small greyish hare, with shorter limbs, and longer recurved tail, carried lying close along the back. The ears,[4] when bent forward, do not reach to the tip of the nose, and thus differ markedly from those of the Brown Hare, but are relatively as long as in the varying hares.

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[1] Genus *Sylvilagus* of Gray.

[2] Subgenus *Neosorex*; see above, p. 127.

[3] *The History of the European Fauna*, 1899, 291: "Its nearest living relatives, as we should almost expect, are found in South America."

[4] Abnormal specimens are known wherein the ears are apparently absent; the deformity may be of various degrees, from those lacking pinnæ, but possessing external apertures, to those in which there is no opening to the exterior (see *Catal. Coll. Roy. College Surgeons*).

The arrangement of the **fur**, which is very soft, especially on the head, resembles that of the hares (see above, p. 152). In healthy animals in good coat, the underfur does not take part in contributing to the general colour, being completely covered by the thick coat of long middle hairs. The extra long dusky hairs are comparatively scarce.

The general **colour** of the upper surface is a grizzled mixture of dusky and buffish tints, slightly darker in some individuals (particularly males), especially near the centre of the back. The nape is clothed with deep "ochraceous buff" underfur, without longer hairs. The limbs are, as a rule, ruddier than the back, but the rump is frequently greyer, especially in winter. The colour passes with moderate abruptness into the white of the inner surface of the limbs and of the under side, which white is interrupted only by a grizzled band passing across the lower throat and chest, and by another across the inguinal region. The ears are slightly rimmed with black posteriorly; they are variably furred, according to season, on the anterior outer side to about the point where they are longitudinally folded; on the remainder of the outer surface, and on the inner margins, they are clothed with fine, short fur, but the median interior surface is hairless. The upper side of the tail is black, slightly grizzled; its lower side is white. The soles of the feet are dirty yellowish or whitish.

Examined closely, the hairs of the underfur of the back are dusky, with the tips near "russet"; on the belly they are white with dusky bases, passing from one type to the other by insensible gradations. The annulated hairs on the back are dusky with a light base, and a subterminal band of light buff; the dusky band next to the base is usually the broadest, and that forming the tip the narrowest. Many intermediate gradations occur between the ringed hairs of the back and the white hairs of the belly. According to Hurst (*Linnean Soc.'s Journ. Zool.*, xxix., 1905, 299, etc.), there are in the hairs two, possibly three pigments, viz., yellow and black certainly, and also, probably, brown or chocolate, the latter apparently in close association with the black.

The winter fur is much thicker, especially on the rump, than that of summer; and the white area of the under side spreads upwards to a distinct, but variable, extent on the rump and hind legs. The flanks, cheeks, and regions surrounding the eyes may also be grey. The whitening seems to be accentuated in Orkney, where specimens inhabiting the hills are said to be "hoary in winter" (Barry, *History of the Orkney Islands*, 1805, 316).

An important **moult** takes place in autumn. This may be observed in individuals in Co. Wexford early in September, but is probably not general until the first frosts, after which rabbits are in heavier and thicker coat, so that their skins are more valuable. In December and January the fur is in fine condition, and I suspect that it undergoes a gradual change throughout the winter. The new hairs, when first appearing, are very similar to those of the old coat, and not conspicuously different, as in the Brown Hare. There is also a spring moult as in the hares; it may not be completed until 7th July (specimen examined at Kilmanock, Co. Wexford), but I have noticed it also on 25th May.

The **young**, by the time they leave the nest, are, except in size, very similar to the adults, but the underfur being more prominent, the hairs less so, they have a woolly appearance. They are usually without the extra long hairs until about the age of two months (Hurst, *op. cit.*, 300), between which time and the third the juvenal coat is shed (Harting, *The Rabbit*, 8, footnote). I have examined one in process of moulting on 13th January 1911. White hairs, sometimes forming a definite patch or spot, are frequently found on the forehead.

There are six **mammæ** arranged in three pairs, a pair pectoral and two pairs abdominal. [Note, however, that Darwin, *Variation of Animals and Plants under Domestication*, 1868, i., 106, writes: "The common wild rabbit always has ten mammæ."]

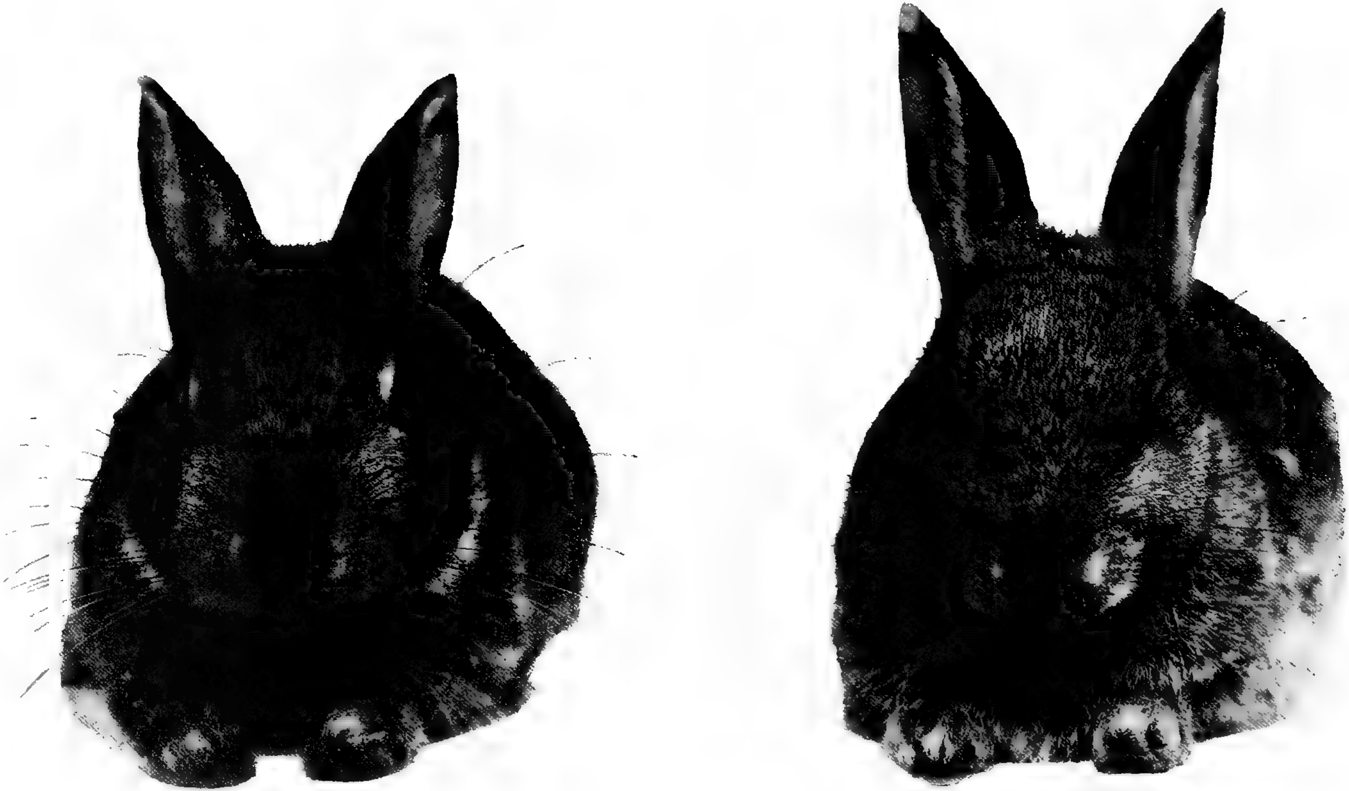
For **age and sex characters**, see above, under *Leporidæ* (pp. 163-165). The blunt heads of the bucks (see Plates XII. and XIII.) are usually unmistakable as compared with the long lean heads of the does. Although widely known, I do not find this fact recorded except in Blaine's *Encyclopædia of Rural Sports*, new ed., 1875, 510.

Numerous **colour variations** occur, and have been long known. They must have been familiar in the sixteenth century according to Gesner (see above, p. 184); Merrett described two as "griseus argenteus" and "niger" in 1666; and about the same date (1675) black rabbits were noticed on an island off Ireland (Westropp, *Proc. Roy. Irish. Acad.*, "Clare Island Survey," pt. 2, Dec. 1911, 75). A passage from Chaucer's *Romaunt of the Rose* was quoted by Rolleston (*op. cit. supra*, p. 193), and would at first sight seem to point to varieties having been familiar objects in the fourteenth century. It runs as follows in Bell's edition of 1855, vii., 60:—

Conies there were also playing,
That comen out of her claperes
Of sundry coloures and maneres,
And maden many a turneiying
Upon the freshe gras spryngyng.

Skeat has, however, most obligingly informed me that the above lines, although undoubtedly written by Chaucer, are a translation from an older poem, *Roman de la Rose*, written about 1260-1270 by the trouvères of northern or central France (see Skeat's "The Student's Chaucer"). According to a quite common custom of Chaucer's,

PLATE XIII.



(1) (2)

Heads of (1) Male and (2) Female Rabbit, to show sexual differences. Photographed by G. D. Croker, Waterford, from specimens obtained at Kilmanock, Co. Wexford, and arranged by M. Parle, gamekeeper.

the first line also did duty in the *Assembly of Foules* (see above, p. 183); the French original is:—

> Connins i avoient qui issoient
> Toute jors hors de lor tesnieres,
> Et en plus de trente manieres
> Aloient entr'eus tornoiant
> Sor l'erbe fresche verdoiant.

The words "of sundry coloures" are not in the original, and were added by Chaucer to fill up the line. Further, Skeat adds that "colour" is but a vague word in Early English; if Chaucer had intended the expression to mean much, he would have used the word "hew-es" = "hues," a native word, the meaning of which was open to no doubt, and which would have filled up the line all right. The passage, therefore, signifies nothing except that rabbits were well known in northern or central France in about 1260-1270.

The most conspicuous colour variations are whole blacks, yellows, browns, silver-greys, or rarely, whites; the silver-greys are usually black in their first coat, and, like grey horses, which start life as blacks, arrive at their final coloration by subsequent assumption of white hairs. Black varieties may be distinguished at birth from the normal type; in the former the pigmented skin is darker and covers the whole body; in the normal the ventral area is pink or flesh-coloured (Hurst, *op. cit.*, 303). There are also parti-coloured varieties, and one or other of the above are sometimes so numerous in warrens as to outnumber the type; for instance, at Hawkstone, Salop, late in the nineteenth century, the late Lord Hill, after unremitting selection through several years, succeeded in establishing a race of pure silver-greys. Sometimes one or other of these varieties appears suddenly in numbers in a definite locality, thrives for a time, and as suddenly disappears. One with long silky hair was mentioned in 1816 by Neill (see also Fleming) as inhabiting the Isle of May and other islands in the Firth of Forth; it was still there down to 1887, and at one time appears to have been in exclusive possession. It is now, however, no longer in existence, having probably been "swamped," as William Evans informs me, by repeated introductions of the ordinary form. Sunk Island, on the Humber, was once famous for a mouse-coloured race, which was extirpated on account of the damage which it caused to the banks (Chamberlayne, *Phil. Trans. Roy. Soc.*, London, 1719, No. 361, 1014-1016; Pennant, *British Zoology*, ed. 2, 1778).

Space does not permit a discussion of the numerous artificially created **domestic forms** of the Rabbit. Many of these are very distinct, both in colour and form, perfectly stable, and breed true. But they can all be traced to the wild parent form, although it is not known when or how it was first domesticated. Neither the ancient Romans nor the Spaniards (see p. 184), mention any domesticated forms.

The 'Himalayan,' a white form, with symmetrical brownish-black ears, nose, feet, and upper side of tail, was described as distinct by Bartlett (*Proc. Zool. Soc.*, London, 23rd June 1857, 159), under the name *Lepus nigripes;* it can, however, be produced by mating silver-greys with the form called 'Chinchillas,' or light silver-greys (Bartlett, *Proc. cit.*, 1861, 40). The study of these varieties has become a separate branch of science, and they are dealt with in detail by fanciers and Mendelians, whose works must be referred to for further information (see Hurst's paper, mentioned above).

Room must, however, be found for a summary of recent work on the causation of yellow, black, and other varieties, a subject which has been considerably elucidated by recent investigations (see Castle, *Science*, 25th January 1907, 151-153; 30th August 1907, 287-291; 21st August 1908, 250-252; Hurst, *op. cit.*).

In a rabbit of normal, or, as Mendelians term it, "agouti" coloration, the pigments of the hairs are laid down in rings as described above, due to a definite cycle of activity in the hair follicles, which form the pigments in a regular sequence. In instances of colour variation the hair follicle may cease to form the pigments in sequence, with the result that they are mixed, instead of being segregated, or, on the other hand, one or more of them may be absent, or present in variable quantity, resulting in various shades of pigmentation.

The normal individual is apparently possessed of several factors:—*Ri*, the factor for ringed hair; *Bl*, the factor for black pigment; the latter possibly mixed with another factor, *Br*, that for brown or chocolate pigment, which is known to be present in mice and cavies; and *Ye*, the factor for yellowish or reddish pigment. An individual lacking *Ri* is black, the black colour being so abundant as to conceal the also present yellow or brown. If a further factor *Bl* be lost, a yellowish or rufous race results. Thus in uniformly coloured rabbits something is lacking which is present in the normal individuals, and it is remarkable that varieties lacking the factor *Ri* and possessing unbarred hair always lack also the white colour of belly and under side of tail which is due to absence of pigment from the terminal portions of hairs in these regions. Blue or blue-grey rabbits are individuals possessing black pigment in a dilute form, while the yellow apparently remains scanty in amount.

White specimens are not, as regards colour, necessarily negative, that is, entirely lacking the power of forming pigment, although some of them may be so, and are then true albinos. Many white individuals lack an æstivating or ferment-like substance, without which pigments cannot be made visible; but in other respects they carry all the colour potentialities of pigmented individuals, which is shown by the results of crosses between the two classes. White specimens may thus occur in any of the above-mentioned categories.

Besides the factors for the various colours there are also factors for formation of patterns, and these are equivalent to partial inhibition of pigment.

The above-mentioned facts are probably true, not only for rabbits, but for cavies and mice; but the subject has been pursued further in the two latter than in the former animals, and for a further account of it reference should be made to the article on the House-Mouse.

Geographical variation:—There are two sub-species, viz., *O. cuniculus cuniculus* (Linnæus), the subject of the present article, and *O. c. huxleyi* (Haeckel, *Hist. de la création des êtres organisés d'après les lois naturelles*, 1874, 130). The latter was described from Porto Santo, near Madeira, where it was introduced about 1418; it is found also in the Azores and Salvage Islands between the Canaries and Madeira. It was noticed in Crete by Bate, and renamed *O. c. cnossius.* It is found throughout the Mediterranean region, and is a small grey form with the hind foot (including claws) reaching only 75 to 85 mm. *O. c. cuniculus*, besides being the Rabbit of the British Islands, is also that of Europe, north of the Mediterranean region.

Hybridism:—See under genus LEPUS.

Dimensions:—See table on next page, wherein only specimens considered to be fully adult are included in the averages; but it is difficult to obtain a number of adults, and it is probable that really old rabbits are comparatively rare, so that an average, to be natural, should include some sub-adults. Although the items are variable, the averages of each lot, except in length of head and body, a measurement difficult to obtain invariably under precisely similar conditions, are very uniform. The length of the hind foot depends on the condition of the claws, and that of the head and body on the treatment which the carcase happens to have received.

Skull (range of nine specimens in British Museum of Natural History):—Occipito-nasal length, 78 to 82; condylo-basal length, 68·6 to 72·8; zygomatic breadth, 37·2 to 41·4; breadth at intero-orbital constriction, 12·4 to 15; breadth at post-orbital constriction, 11 to 14; breadth of brain-case, 27 to 29·8; nasals measured by diagonal, 35·4 to 38; greatest breadth of both nasals together, 14 to 17·2; length of diastema, 22·4 to 24; length of mandible, 59 to 63·4; length of maxillary tooth-row, 14·2 to 15·6; length of mandibular tooth-row, 14·2 to 16·2.

Weight (in lbs. and oz.):—This depends to a great extent on the nature of the ground, the food and the time of year. On the analogy of the hares, does should be heavier than bucks, but the latter appear to the eye to be more massively built, and Simpson (*op. cit.*), Cocks, and others find that they are, as a rule, larger and heavier than

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail.		Hind foot, with claws.	Ear.		Weight.	
		Extreme length.	Vertebræ.		To notch.	To nape.	Lbs.	Oz.
MALES FROM KILMANOCK, CO. WEXFORD:—								
1. 5th January 1911 .	406	93	71	95	68	84	..	..
2. Do. . . .	406	89	60	94	63	73	..	..
3. Do. . . .	406	90	68	90	62	78	..	.
4. Do. . . .	406	93	71	99	68	75	..	.
5. Do. . . .	419	82	65	99	69	76	..	..
6. Do. . .	406	81	64	91	70	78	..	
7. 3rd March 1911	457	104	81	100	68	..	..	..
Average of 7 .	415	90	68·5	95·5	66·8	77	..	..
FEMALES FROM KILMANOCK, CO. WEXFORD:—								
1. 20th Dec. 1909 .	432	82	62	88	66	..	..	.
2. Do. . .	432	82	61	88	70	..	..	.
3. Do. . . .	432	85	63	86	64	..	..	.
4. 5th January 1911	412	98	66	92	64	79	..	.
5. Do.	406	98	80	98	66	75	..	..
6. Do.	419	97	74	105	69	74	.	..
7. Do. . .	406	94	74	94	69	76	..	..
8. Do. . . .	393	95	66	96	64	70	..	..
9. 3rd March 1911 .	393	86	65	93	66	77	..	..
10. Do. . . .	406	91	76	94	68	76	..	..
11. Do. .	419	101	69	98	69	..	..	..
12. Do. .	457	96	69	97	71		..	..
13. Do. . .	444	100	65	94	65	..	..	..
14. Do. . . .	438	102	65	90	63		..	..
15. Do. . . .	419	98	70	84	66	..	..	..
16. Do. . .	444	97	68	93	68	..	..	..
Average of 16 .	422	94	68	93	66	75 (7 items)	..	..
17. Sub-adult, 3rd March 1911 (mandibles ankylosed, but ear tearable)	431	..	..	87	..	..	..	..
18. Immature, 13th Jan. 1911 . .	279	81	55	78	58	72	..	..
19. Do., 10th Aug. 1911	320	84	59	75	57	70	.	..
20. Do., 5th Sept. 1911	180	..	26	45	34	..	..	..
FEMALES FROM OTHER LOCALITIES:—								
21. Tidmarsh, Berkshire, 10th Dec. 1896 * . .	392	..	64	86	70	..	..	..
22. Ditchling, Sussex, Sept. 1908 * .	386		77	85	69	..	..	..
23. Do. do.* .	385	.	71	86	69	.	..	..
24. Lezayne, Isle of Man, 10th Dec. 1900 * . .	437	..	66	91	70	..	..	..
25. Clandeboye, Co. Down, Ireland, 10th Feb. 1905 *	408	..	63	85	65	..	3	4·25
Average . .	401	..	68	86	68	..	.	..
Average of both sexes in all tables . .	416	93	68	92	67	76	..	..
Proportionate lengths (approximate), head and body being reduced to 100, and all other dimensions proportionally .	100	22	16	22	16	18	.	..

* These particulars were copied from the labels on specimens in the British Museum of Natural History.

the does. The two sexes are, however, in this respect so similar that discrepancies are probably due to the disturbing influence of the sexual functions, present through nine months of the year.

Numbers of rabbits have been weighed by sportsmen and naturalists, who have published details of a few specimens reaching well over 5. But after long experience as an editor of the *Field*, Harting (*Field*, 17th December 1898, 981, and *op. cit. supra*) put the average at 3 to 3½, and could not vouch for any heavier weight from personal experience. Reliable correspondents had, however, sent him notes of several over 4, and of two, apparently wild, of 4^{13} and 4^{14} respectively. He believes that every instance of weights exceeding 5 is due to the turning down of domestic animals, as is frequently done in order to increase the size of the wild stock. Simpson writes (*Field*, 24th December 1898, 1014) very much in agreement with Harting, reporting that having weighed many in October, when they are at their best, none exceeded 2^{8} or 2^{12}, paunched, which weight he considers the average, although on good pasture another pound might be added. Owing to the numbers of small, ill-fed specimens sent to the markets from poor warrens, the general average of those handled by big dealers is said by Simpson (*op. cit.*, 35) not to exceed 2 when paunched.

At Kilmanock, Co. Wexford, where there is no record of any rabbits having been turned down for many years, in December 1887 nineteen totalled about 65^{8}, averaging 3^{7}, the heaviest being almost 4. A large one, specially selected for its size, on 1st January 1892 was also under 4. It should be noted that an accidentally emasculated buck would attain a weight much above the average, and such an individual might account for the specially heavy weights occasionally recorded.

Distinguishing characters:—The size of the Rabbit is quite distinctive. The hind foot, including claws, rarely measures above 100 mm., as compared with at least 130 in the hares. The best way to distinguish a quite young one from a leveret of *L. europæus* is by its grey rather than ochraceous colour. As compared with the Scottish and Irish hares the long tail is characteristic; this, including the hairs, is usually about equal to, or slightly shorter than, the hind foot, whereas the hind foot of a young hare may be double the length of the tail.

Apart from its small size, the skull may be distinguished (amongst other characters) by the narrow posterior nares, always narrower than the breadth of the bony palate; the narrow superciliary processes; upper incisors with roots not visible through the bone; and the deep anteriorly thickened zygomata.

The Rabbit is one of the commonest British mammals, but its habits present many points of interest, which in some respects cannot be considered better known than those of rarer and less familiar species.[1]

As compared with a hare, it is a generalised animal, a digger and yet a runner. But although it digs, and digs well,[2] its skill in this respect has not been accompanied by the serious loss of locomotive powers which specially fossorial limbs impose upon their possessors.

It is, however, unfitted by its organisation for that long continued and rapid course by which the hares are distinguished. Instead, it seeks safety and shelter in deep holes of its own construction, and in places where the work of excavation is easy it associates in large societies. A big burrow is a very complicated excavation, which may descend to a depth of several feet, and does not seem to be built on any specified plan. In fact, its ramifications[3] are the result of the promiscuous activity of many generations of inhabitants, each member of which has from time to time taken a turn in an unorganised way at improving it. Certain features are, however, common to all burrows. The main entrance or entrances are constructed from the outside, and may be easily recognised by the bare spaces at their mouths, which are formed by the excavated soil. This is kept free of vegetation by the passing and repassing over it of the inmates, which also sit on it, and leave there a portion of their droppings. Sometimes also a bone or two of defunct rabbits, or the remains of the old bedding used in a nursery, are recognisable. The inhabitants do not allow large heaps to accumulate in front of or around their burrows, but work the soil away from the entrances, so that it forms long, narrow, rather furrow-like mounds of shallow height; and, if the burrow opens on the side of a hill, the soil is always thrown downwards in the easiest direction. A feature

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[1] Indebtedness is gladly acknowledged in preparing this article to two works on the Rabbit, by J. E. Harting and J. Simpson, the titles of which are mentioned above on pages 178 and 191.

[2] "It can soon drive a tunnel into the hardest loam or dry clay; and I have known it burrow deeply in a surface seam of coal, and scatter the lumps yards away from the entrance."—Simpson, *op. cit.*, 16.

[3] Few plans of burrows seem to have been published, but there is one in P. Anderson Graham's *Country Pastimes for Boys*, 1908, 300, fig. 171; another in Miss M. D. Haviland's *Lives of the Fur Folk*, 1910, 89; and some simple ones in Owen Jones and Marcus Woodward's *Woodcraft*, 1910, 89 and 92.

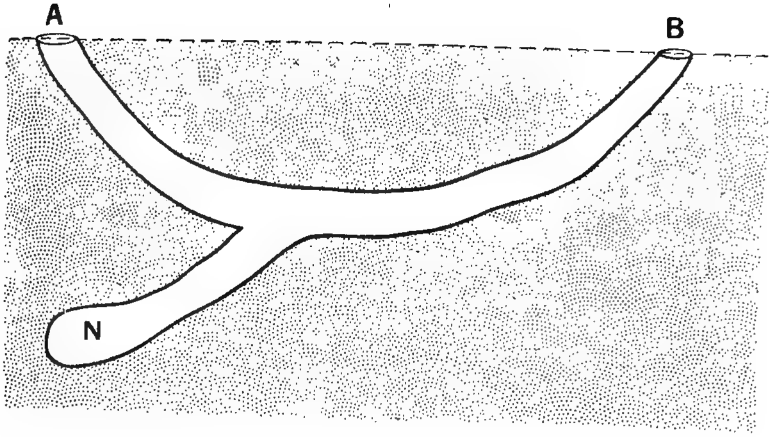

FIG. 35.—SECTION OF SIMPLE BURROW IN OPEN FIELD.

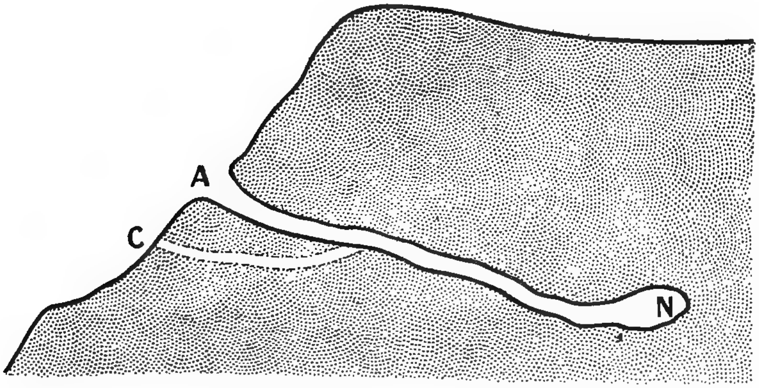

FIG. 36.—SECTION OF OLD RABBIT BURROW (C); enlarged by fox and badger (A).

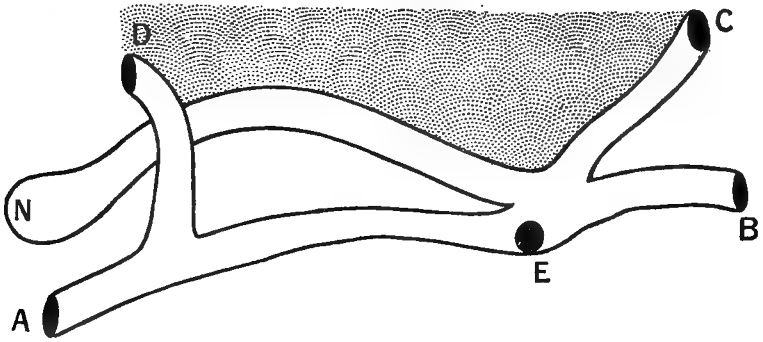

FIG. 37.—PLAN OF COMPLICATED BURROW WITH FIVE ENTRANCES.
From A to B is 45 feet.

The above are diagrammatic, and N is the sleeping compartment or nursery; A, B, C, D, E are entrances.

Figs. 35, 36, 37 drawn by G. Dollman, from information supplied by Owen Jones.

of the mounds of excavation is that they generally have fairly definite edges, yet there is so little soil at the mouth of some big burrows that it must also be scattered broadcast. Sometimes a worker, either finding the labour too heavy in the original direction, or, for some other reason, changes it, so that the mound bifurcates.

Exactly how the work is performed is a debatable question. The main labour of digging must always, of course, fall upon the fore paws, assisted, where an obstacle such as a stone has to be removed, by the teeth.[1] In removing the soil, no doubt the usual method is to pull the material backwards with the fore feet, throwing it out bodily between the hind legs when necessary. Sometimes the animal walks backwards, working its hind feet alternately, and their action is so strong that it results in scattering the soil for a distance. As Mr Owen Jones has well put[2] it, the fore feet are used for throwing back the soil a little way, the hind legs for flinging it a long way. Mr Jones informs me that he has twice seen a rabbit thus flinging back the excavated earth, and on one occasion he was at such close quarters that he caught the operator by a hind leg with his hand. The action in both cases closely resembles that of a dog, which in its vigorous backward cannonading may often reach a man's eye.

Although most of the burrows are constructed from the outside, there are always a certain number of entrances which show no excavation mound, and have evidently been opened from the inside. The latter frequently go down almost perpendicularly for a distance of three or four feet, and their mouths are small, devoid of bare spaces around them, and usually concealed by vegetation. These are the emergency exits, scoot-, scout-,[3] or pop-holes, which a rabbit uses only in order to escape from an enemy inside the burrow. They often present an appearance of having been ingeniously concealed; but it seems probable that this is due rather to accident than to a display of forethought[4] on the part of the rodents. Indeed, most holes

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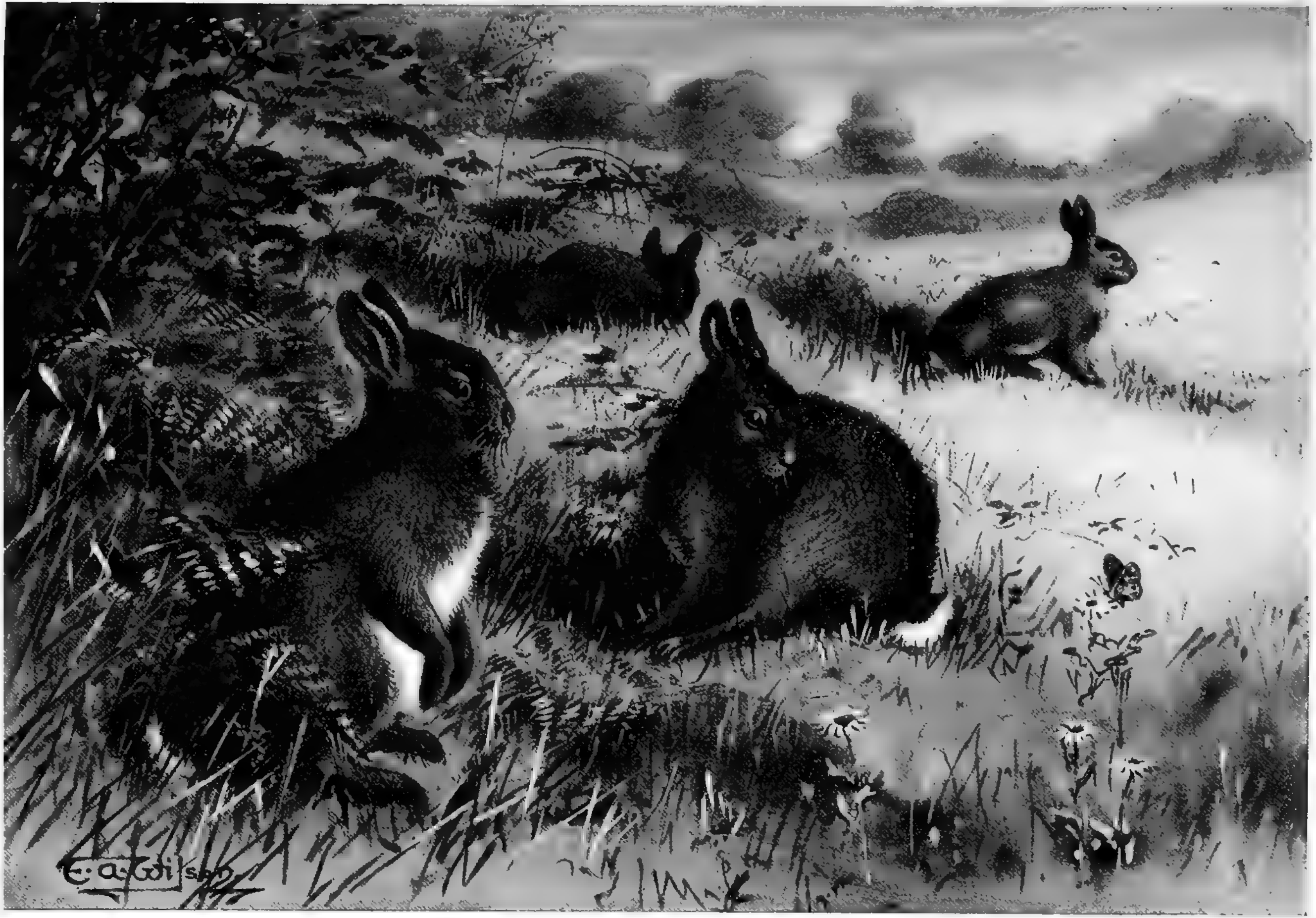
[1] Richard Kearton, *The Fairyland of Living Things*, 1907, 80.

[2] *In lit.*, 15th April 1911.

[3] From "scoot"=to make off quickly.

[4] As against this, however, is the fact that in sandy and loamy soils an excavation may be carried to within a half inch or so of the surface. When pressed by an enemy from within, a rabbit will push through the thin, unexcavated portion and escape.

PLATE XIV.



RABBITS.

that are not frequently used soon become, in the natural course of events, hidden by overgrowing vegetation, and where vegetation is scarce, as on a bare hillside, scout-holes may be as conspicuous as the regular entrance holes.

The mound of excavation is frequently added to and freshened by renewed digging, especially in autumn, when the inmates seem to be restless, and are, perhaps, unconsciously preparing for the approach of winter; or, it may be, that the autumnal outburst of activity is due to the return home of sojourners above ground during the warm weather.[1]

The occupants of an ordinary "burry" sleep on the bare earth, in chambers running off blindly from the passages. Their main object is evidently to escape damp and draughts. Warmth is probably secured by several animals huddling up together, for no bedding materials are ever carried in for the use of the adults.

The size and capacity of some burrows may be best realised by considering the number of animals of different species and habits which may be found in them. Thus Col. E. A. Butler informed Mr J. G. Millais that on one occasion when ferreting he bolted a fox, a cat, a stoat, and several rabbits and rats out of the same earth. It is difficult from the outside to imagine the arrangement whereby a menage composed of so many mutually hostile elements came to be carried on. Probably the smaller occupants construct and retire to passages of suitable diameter, where they are safe from their dangerous fellow-lodgers. Besides this, the interior must be intensely dark, and the atmosphere so "thick" and full of mixed odours, that the exquisite powers of scent possessed by both rodents and carnivores cannot be brought into play, so that they must depend on their hearing and touch for knowledge of their neighbours. The result is that a close approach is possible by mutually antagonistic animals, which can thus enjoy in common a home offering exceptional comfort; and that, so far as the Rabbit is concerned, means

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Henry Laver writes me that in the light soils of Essex these uncompleted bolt-holes are very common, and that he has seen scores of rabbits escape in this way.

[1] See Owen Jones and Marcus Woodward, *A Gamekeeper's Notebook*, 1910, 212.

dry lying in the immediate neighbourhood of good rich pasture.[1]

The large rabbit-burrow, of which Fig. 38 is a plan, was selected for examination on account of its situation in an open field, where, the soil being stony, the rabbits were not likely to tunnel deeply underground. This expectation was realised, no portion of the passages having a greater depth at its floor than 28 inches, and most of the floors lying only about 18 inches below the surface. With two exceptions, the tunnels are drawn in one plane, but the distance in inches from their floors to the surface of the soil is indicated. The average diameter of the tunnels was about 6 inches, increasing at certain situations, so as to reach about 1 foot, in at least one direction, but not being truly circular.

There were, excluding the two short blind tunnels marked B, B, seven openings to the exterior (A, A). The works were divided into two sections, the neighbouring mouths of which opened into a shallow pit or depression (H) shown near the middle of the plan. This pit had the appearance of having originated through subsidence caused by active digging close to the surface. The four tunnels opening into this pit may at one time have been continuous, and their mouths must certainly have been originally much closer together. While engaged in excavation, a foot of one of the men penetrated and exposed a portion of the blind terminal opening into the pit, and it would have taken very little working on the part of the rabbits to convert this into another mouth.

The burrow was remarkable for its abrupt, as well as for its gradual turnings; the former, no doubt, often owed their existence to the difficulty of carrying on the tunnels in the direction originally intended through the hard ground. This is what had probably happened at D, and in other places where short blind alleys or increases of diameter are marked in the plan; in other cases the chambers may be regarded as incipient tunnels. One or two enlargements (N, N), either terminal or lateral, were obviously sleeping or resting places; but these were seldom encountered; one contained two pellets of droppings.

Two remarkable circular tunnels will be noticed at F, F, and

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[1] Simpson, *op. cit.*, 16.

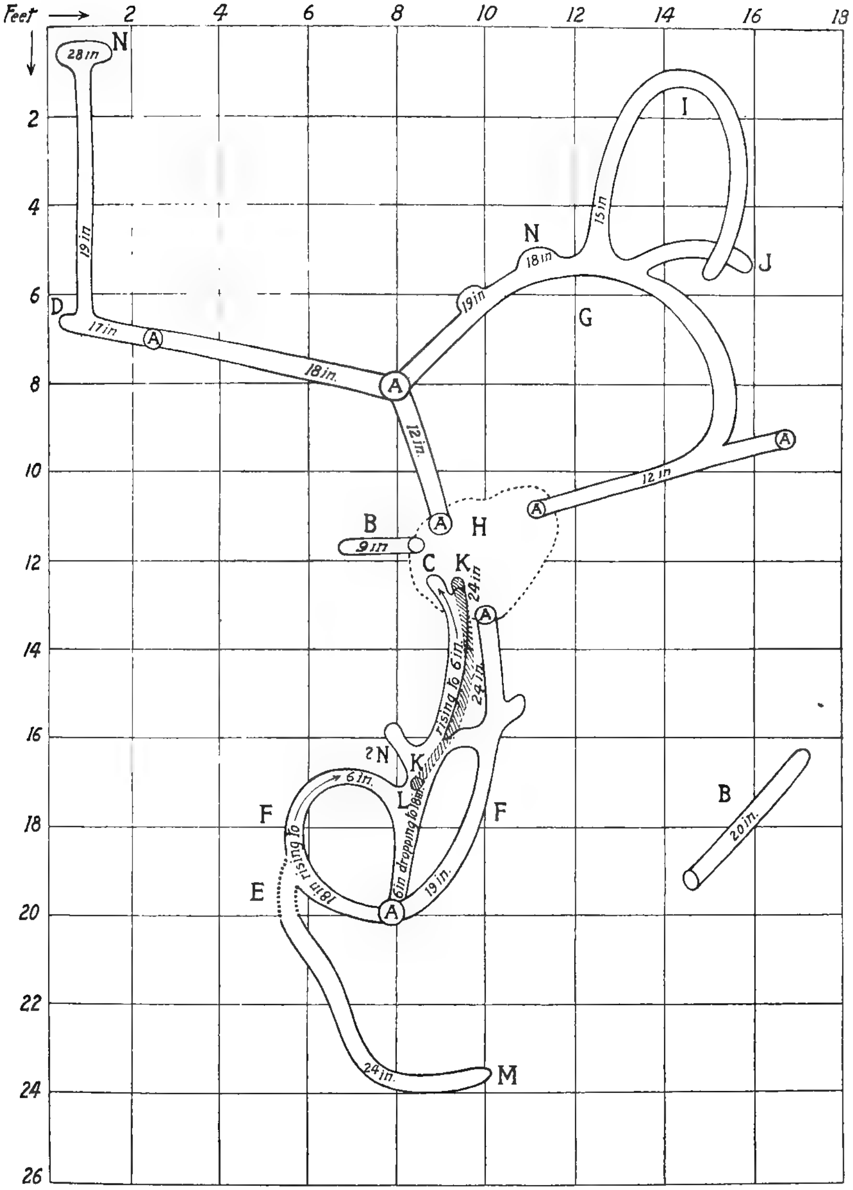
Feet →
2
4
6
8
10
12
14
16
18
2
4
6
8
10
12
14
16
18
20
22
24
26
N
28 in
19 in
D
17 in
A
18 in.
A
12 in.
19 in
N
18 in
15 in
I
J
G
A
12 in
A
H
B
9 in
C
K
24 in
A
rising to 6 in.
24 in
?N
K
L
6 in.
F
F
rising to
18 in rising to
6 in dropping to 18 in.
19 in.
E
A
24 in.
M
B
20 in.

FIG. 38.—PLAN (Diagrammatic) OF A RABBIT-BURROW AT CAPPAGH, CO. WATERFORD, excavated by permission of R. J. Ussher, 12th December 1911.

From a sketch by G. E. H. B.-H.

a third larger one at G, which would serve excellently the purpose of enabling the inhabitants to avoid the pursuit of a stoat or ferret. At I is shown an uncompleted circular gallery, the termination of which lies above another deeper gallery J. A second deep gallery (K, K) is shown by shaded lines; its mouth (L) opened on the floor of one of the main tunnels. A tunnel ending blindly at M was not traced so as to connect with the main burrow, but its probable course is indicated by the broken lines at E.

The appearance of the galleries was cold and uncomfortable, and it is believed that they are not much used in winter.

In Fig. 39 is shown a plan of a second rabbit-burrow, which, having been constructed in ordinary soil, descended to a greater depth than that shown in Fig. 38, and was more difficult to excavate. Although the diameter was on the average broader than that of No. 38, it was in places, as at Z, even smaller than the latter. There was only one sleeping place (N), but the excavation was, for lack of time, not completed, and the burrow may possibly have communicated by U with the partially excavated tunnel Y.

Sandy heaths covered with furze are favourite resorts of rabbits. The soil is easily penetrated, and the furze affords at once a secure cover for retreat, and a wholesome and never-failing supply of food; the young tops of the plants are constantly eaten down, and the bushes present the appearance of a solid mass, with the surface rounded off evenly as high as the animals can reach when standing on their hind legs. On moors, where the soil is very wet, they often refrain from burrowing, and content themselves with runs and galleries formed in the long, matted heather and herbage.[1] In such localities they lie like hares in "forms," and it is no doubt this propensity, which is always very evident in fine weather when cover is abundant, that has given rise to the popular belief amongst sportsmen that there are two distinct varieties. One, the ordinary or "burrow rabbit," is known in Hertfordshire and

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[1] As in heather and crowberry on Boar Flat moor, at the head of Swineshaw Valley (Cheshire), near Oldham; and on a large scale on the Peak hills of Kinder Scout, Derbyshire, F. J. Stubbs, *Report Oldham Microscop. Soc. and Field Club*, 1905-6-7, 30, 1908, and in *lit.* This is the normal habit of the Mexican Pygmy Rabbit *Romerolagus nelsoni;* see E. W. Nelson, *North Amer. Fauna*, No. 29, 280.

Kent as the "stub-rabbit";[1] the other is called the "bush rabbit" in Ireland,[2] as well as in other localities—for instance, in Bedfordshire, Hertfordshire, and Surrey.[3]

A rabbit-warren presents towards evening a curious and not uninteresting spectacle. The ground everywhere pierced with deep and tortuous holes, the absence of all esculent vegetation for some distance round, and the playful gambols and rapid retreat of the inhabitants, as they either sport in security or fly from the approach of danger, are circumstances which at once indicate the peculiar habits of the species and present a lively and amusing scene.

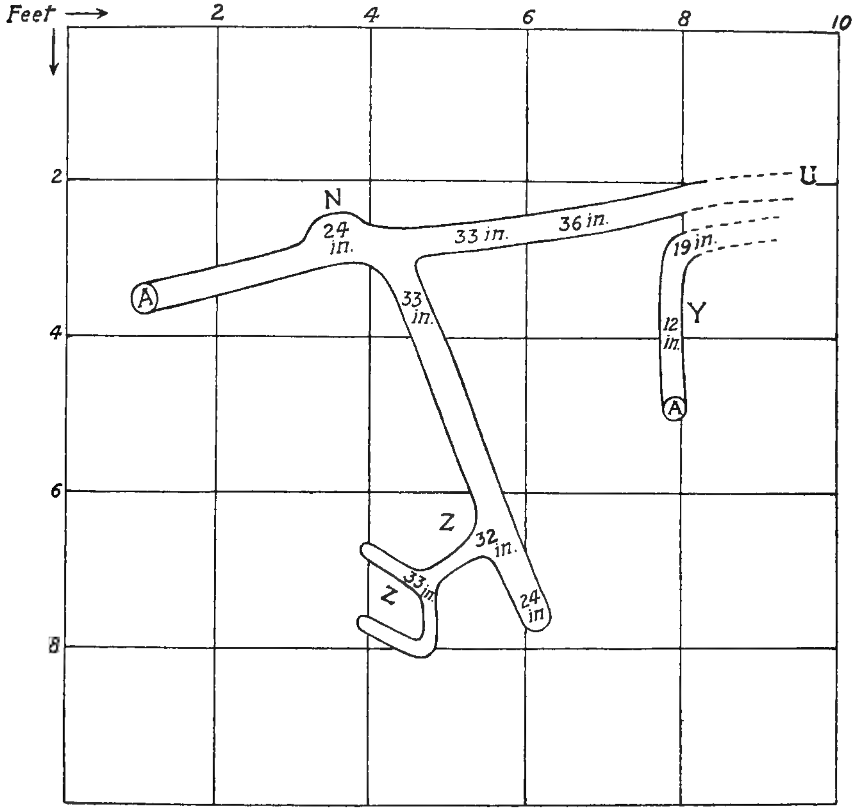

Fig. 39.—Plan of a portion of a second Burrow partially excavated at Cappagh, Co. Waterford, by permission of R. J. Ussher, December 1911. From a sketch by G. E. H. B.-H.

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[1] Rev. G. F. Dawson, *Zoologist*, 1845, 903; see also 969.

[2] William Thompson.

[3] L. E. Adams.

The Rabbit is certainly polygamous when abundant. The doe is evidently polyœstrous, with a long sexual season, and her several litters may appear during winter as well as in summer, but much less frequently between September and December,[1] or, in cold northern localities, between September and February.[2] The period of gestation lasts for thirty days, and from three to five or six young are most usually brought forth at a time. Instances are known in which the number found together in a nest amounted to eleven,[3] and even to fourteen,[4] but possibly the larger numbers may have been due to superfœtation, or to a combination of the litters of two mothers. The doe is believed to commence breeding when six months old, but since a rabbit becomes fully grown in about three months, and the domestic forms breed at the latter age, that period may be regarded as marking the advent of sexual maturity in wild does also, although no definite observations appear to have been placed on record.

Since the breeding season, in the south at all events, lasts nearly throughout the year, and since several litters may be born of one mother in a year, the number of young in each case depends on the season. As the result of over four years' observations in South Buckinghamshire, Mr A. H. Cocks finds that the average number in a litter increases from between two and three in October to nearly six in June, and then drops again to October. The average is five (plus different fractions) for March, April, May, June, and July. The rise or drop is gradual, except between September and October (downwards) and November and December (upwards). The ratio of the number of litters corresponds fairly well with the monthly average of young per litter, being probably greatest between March and June, and the reverse in October and November, but the proportional rise and fall is much greater. Mr Cocks met with eight young on four occasions in May, June, and

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[1] For an instance of midwinter young under extremely unfavourable circumstances, see J. A. Harvie-Brown's account (*Zoologist*, 1867, 604) of a breeding-nest composed entirely of rabbit's wool placed under four inches of frozen ground at Dunipace, Stirlingshire, Scotland, in early January.

[2] Simpson, *op. cit.*, 20.

[3] *E.g.*, E. R. Alston in Bell, ed. 2, 345; once at Kilmanock.

[4] George Sim, 72, on the authority of a keeper.

July, and nine once only, viz., on 29th March 1901. They are born blind and deaf, and nearly naked, and are thus unlike leverets, which are covered with fur and have the eyes open at birth. The ears are said not to gain the power of motion until the tenth day; on the twelfth they are completely open, and on the thirteenth they may be erected. Sight begins on the eleventh,[1] and shortly afterwards the young leave the nest for short periods preparatory to their final exit. They probably eat grass as soon as they can run, and are independent of their mother by the third or fourth week.

Messrs C. S. Minot and E. Taylor[2] have studied the rate of growth of young rabbits both before and after birth, and find that from the ninth to the fifteenth day the embryo adds 704 per cent. to its weight daily. Afterwards the average daily addition drops enormously, being only 212 per cent. from the fifteenth to the twentieth day. The figures suggest that in younger embryos the rate of increase may be very much greater, amounting to possibly over 1000 per cent. per day before the ninth day. Four days after birth a young male rabbit is capable of adding over 17 per cent. to its weight in a single day. The percentage increment then drops rapidly, until at the age of twenty-three days the addition is only a little over 6 per cent. each day. After about the fifty-fifth day the decline in the growth rate becomes more gradual.

The doe pairs again within a few hours after the birth of her young, and if no conception results, pairing takes place again at intervals varying from ten to twenty-one days, until either pregnancy ensues or the sexual season terminates.[3] She is frequently found to be pregnant whilst suckling a previous litter. Superfœtation is said to occur, but must be very rare indeed, since Mr Jones, although he has paunched thousands, has never noticed a case of it, and other gamekeepers have given similar testimony. Mr Cocks has, however, met with one instance; and other cases of the production of litters at intervals of from two to nine days have been placed on record.[1]

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[1] *Fide* Harting, *op. cit. supra*, 8, footnote, apparently from W. B. Daniel, *Rural Sports*, 1801, i., 495; Daniel, however, got the fact from Cartwright, who wrote of domestic rabbits in his *Journal on the Coast of Labrador*, 1792, but, the latter work being without an index, I have been unable to find the original passage.

[2] "The Problem of Age, Growth, and Death," *Popular Science Monthly*, lxxi., 1907; reprinted London, 1908; see also Normentafeln zur Entwicklungsgeschichte der Wirbelthiere (Jena); No. 5, 1905.

[3] W. Heape, *Quart. Journ. Microscop. Sci.*, 1900. See F. H. A. Marshall, *The Physiology of Reproduction*, 1910, 41.

It is evident from the above facts that the multiplication of this species is extremely rapid;[2] so much so that although, until the recent fall in prices, it was capable of yielding, if properly managed, both profit and pleasure to sportsmen, on arable farms it often becomes an intolerable scourge to the agriculturist, unless its numbers are constantly kept in check. Since the destruction of our native beasts and birds of prey, most of which are very fond of rabbit's flesh, its most deadly foe is man, who pursues it with guns, traps, nets, dogs, and ferrets. But rats are no mean rivals, and in the summer they live to a great extent in rabbit-burrows, where they kill and eat the young; and domestic cats are also very fond of poaching.

The effect of rabbits on a local flora is often more considerable than is generally known, and is both destructive and constructive. The original vegetation is usually destroyed in the immediate neighbourhood of a warren, to be replaced by a new flora. The details are, no doubt, different according to the locality and the nature of the soil. On good land the grass gives way, and thistles, nettles, and other weeds gain a footing from which it is hard to eject them. Where the soil is loose, as when there are sandhills, the damage is most marked.

The interaction of rabbits and vegetation in Breckland, a big sandy district surrounding the town of Thetford, on the borders of Norfolk and Suffolk, has been studied by Mr A. Wallis.[3] He has shown that grass, gorse, and ling are destroyed by being eaten, and sand sedge, for which the rabbits have no liking, then flourishes. But burrowing on a large scale produces at first what are practically deserts. "The rabbits," writes Mr Wallis, "bore into a gently sloping hillside, the soil falls down, a slight escarpment is made, and they bore again. This process, continually repeated, gives rise to considerable extents of loose sand, bounded on the upper side by a miniature cliff full of burrows, on the lower side merging almost imperceptibly into the hillside. The action of the wind upon the loose sand is such as by purely mechanical means to prohibit the growth of any vegetable life, but where stones offer any protection against the moving grains, *Cladonia* (lichen) will often be found. This may either cover in time the whole bare area, or give way to *Festuca ovina* (sheep's fescue-grass), which in turn gives way to *Carex* (sedge). Towards the lower edge the *Cladonia* increases considerably, with here and there a tuft of *Festuca ovina* and the straight lines of Carex shoots, until the normal growth of the undisturbed hillside is reached."

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[1] G. Griffiths, *Field*, 4th October 1890, 501 (two litters of six each, at interval of two days); J. E. H. Hasted, *Field*, 16th April 1892, 545 (litters of four and three, with five days' interval; litter of two, followed nine days later by litter of one).

[2] The rate of multiplication has, however, been frequently exaggerated, and a commercial estimate of the average number reaching a good saleable size from a single pair in one season is, even in a favourable climate, not over twelve to fifteen (Simpson, *op. cit.*, 20).

[3] In J. E. Marr and A. E. Shipley's *Handbook to the Natural History of Cambridgeshire*, 1904, 226-228.

One class of plants seems to owe its existence in Breckland entirely to the rabbit-burrows. They are the annuals, always rare plants in the sandy wastes of this district, and especially those called cornfield annuals. These appear on the excavation heaps of burrows which are little frequented or disused, and amongst them may be mentioned the hemlock, storksbill, wall and vernal speedwells, early and changing forget-me-nots, the field cudweed, and the early hair grass. Later on the annuals are succeeded by perennials, differing, however, from those found growing on the surrounding soil. These perennials "seem to hold their ground well, particularly if the ground is loose and very dry, as is the case upon the hillocks which are so often chosen by the rabbits for their holes."

According to Mr Wallis, the annuals "depend for their very existence upon constant and regular disturbance of the soil. Originally such plants, in those portions of the world where they had not invaded the cultivated land of primitive man, must have led a precarious existence upon landslips, bare and crumbling river banks, but principally upon the earths of burrowing animals. It is on the rabbit earths, and on these alone, that in the wilder portions annuals can exist. We see to-day the rabbit performing, in this quiet corner of England, his ancient role of agriculturist."

The influence of rabbits on the general fauna of the country is probably not less important than on the vegetation. The universal habit of trapping these rodents has everywhere resulted in a great destruction of all the carnivora, even where there existed no special intention to destroy the latter. It may safely be said that indiscriminate and unsupervised trapping of rabbits must eventually end in the complete extermination of every animal using their burrows, except the most noxious of all, the rats, and even these are killed in large numbers by rabbit-trappers.

When the doe is about to give birth to her young, she frequently forms a separate burrow, generally known as a "stop" or "stab," a few feet long, at the bottom of which she makes a warm nest of grass or moss, lined with fur plucked from her own belly. This breeding-burrow is often placed in an open field far away from any warren, and it has only one entrance. The mother covers over this single entrance with earth, which she rams in very tightly, and, unless in exceptional circumstances, visits her offspring only under cover of the night. When the young bunnies are nearly old enough to come out and run, she leaves a small opening in the plug, which opening is allowed to increase daily until the time of final exit.[1] Mr Kearton[2] has published two photographs of a breeding-nest, both blocked up and open, and states that in this particular case some hay had been taken from a sheep-foddering station close by and scattered over the closed entrance. No doubt the object of the special breeding-nest is to protect the young from the murderous propensities of the polygamous males, quite as much as from carnivorous enemies.

But a great number of young are dropped in the main burrows,[3] without any partition to separate them from its other occupants, and over these, no doubt, the mother keeps watch during the day and for a portion of the night. The instinct to secrete the young is, therefore, only partially

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[1] Jones, *Woodcraft*, 92.

[2] *Op. cit.*, pp. 178-79.

[3] Jones writes me that he has dug out hundreds of new-born young from ordinary burrows, none of which showed any signs of having been stopped. On 5th May 1886 I found two such litters of different ages in separate parts of a single burrow.

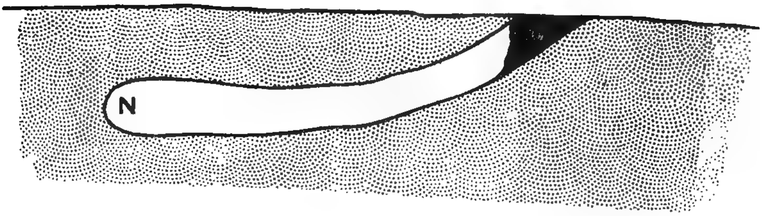

FIG. 40.—SECTION OF CLOSED STOP OR NURSERY.
(Length, 4 or 5 feet.)

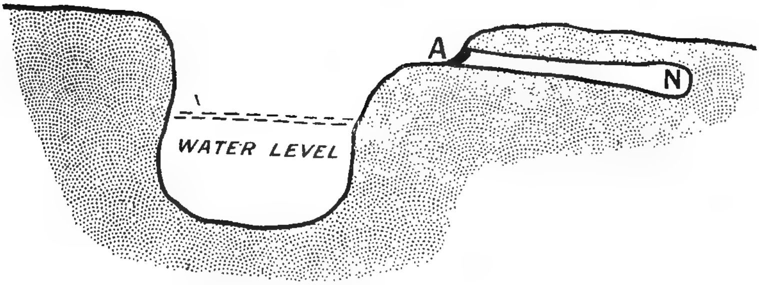

FIG. 41.—SECTION OF CLOSED STOP AT SIDE OF MARSH DYKE.
(Length, 4 or 5 feet.)

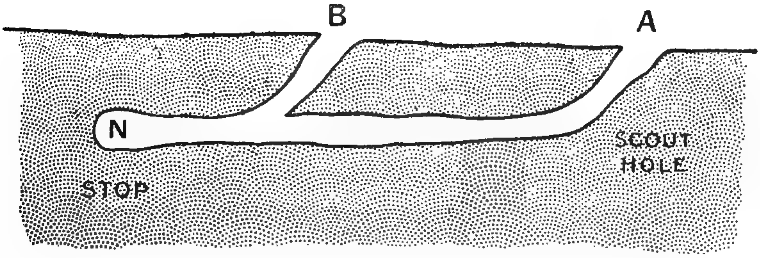

FIG. 42.—SECTION OF STOP ENLARGED BY A SOLITARY OLD RABBIT, and scout- or bolt-hole added at A. B is the original entrance.

(No. 42 is after Owen Jones and Marcus Woodward, *Woodcraft*, 1910, 92.)

The above are diagrammatic, and N is the sleeping compartment or nursery, A and B the entrances.

Figs. drawn by M. B.-H.

developed, and the stops are sometimes placed so near a main burrow that every member of the colony must know of its existence, especially on rocky ground where the noise attending excavation must be considerable.

Few naturalists seem to have seen a doe at work closing her nursery, and there has recently been some discussion[1] as to exactly what method she employs. Daniel[2] and William Bingley[3] stated that the burrow is closed "by means of her hinder parts"; Sir Harry Johnston, that the mother digs with her fore and flings backwards with her hind feet; but it was left to Mr C. J. Davis[4] to describe the efforts of a domestic rabbit to close the entrance of her nesting-box. This she did by flinging sawdust against it through her widespread hind legs, which, be it noted, is the manner of digging in dogs. There is probably a good deal of variation in method, but none of those mentioned above would explain the firm and deliberately careful manner in which the hole is usually closed.[5] It seems likely that the most correct account is that of Mr Hugh Wormald,[6] written from observation of a domesticated wild rabbit. This doe used to turn her back to the nursery compartment of her hutch, and (with her fore feet) scrape all the available grass, sand, and earth into a pile in front of the hole; she then pushed the collected material into the aperture with her fore feet until she had the hole closed. At first she kept the young completely blocked in all day and only visited them by night. When they could see and run a little she used to open the hole in the evenings and let them out one at a time to suckle, after which she blocked them in again. When they grew bigger the doe would go to the open door of the nursery, stamp and give a squeaking grunt, when all the young would run to her to be fed.

A somewhat similar description is that of Mr J. P. Nunn,[7] who wrote of two does of the lop-eared domestic breed that, having first scraped the earth up into little heaps, they arched their backs, whereby they got their hind feet nearly up to the heaps;

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[1] Initiated by the late Henry Scherren, *Field*, 27th November 1909, 975.

[2] *Op. cit.*, i., 488.

[3] P. 316.

[4] *Field*, 4th December 1909, 1049.

[5] As shown by the fact that in wet weather the soil moved by a doe rabbit becomes worked into lumps (Jones).

[6] *Field*, 4th December 1909, 1049.

[7] *Journ. cit.*, 7th March 1908, 410.

then, by placing their front feet against the heaps, they pressed them forward as far as their bodies would reach or allow, and by repeating this simple operation closed the burrow.

Occasionally, from one cause or another, the young are laid like leverets in a "form" above ground.[1] In August 1904 I found four young rabbits thus deposited. Their eyes had not opened, so they were less than ten days old; yet they were shy and cross, and grunted out their strong displeasure at being handled. Another remarkable exception to the general rule was related by Mr L. Hardy, who stated that five young rabbits were found inside an old scarecrow near Oakham;[2] and Mr Jones writes me that he has known of them having been dropped on a rick or under a heap of straw.

The Rabbit is a careful mother, but sometimes when her young are examined she is so frightened that she never returns to them. At other times she does not appear to object to interference, if the nursery is not too much disturbed. Occasionally prudence makes her alter the position of her young in the stop, sometimes increasing its length,[3] or she will remove them in her mouth to a place of greater safety. There is a charming picture by Mr G. E. Lodge of a doe thus engaged, in Mr Harting's book on the Rabbit.[4] Timid though she may naturally be, she has been known to attack and defeat a carrion crow, a weasel, and even the much more formidable stoat in defence of her young.[5] A pleasing account of rescue was told by Mr T. D. White,[6] who saw a rabbit pursue a stoat as it ran away with a young one in its mouth. Three times the rabbit, turning suddenly, kicked the stoat with its hind feet and sent it flying ten or fifteen yards down the hillside. Eventually it recaptured the (probably dead) young one and carried it back to the burrow from which it had been abstracted. The hind legs are the regular weapons of attack in fights between rabbits, the combatants bounding over each other like fighting cocks; but they also employ their incisor teeth and the strong claws of their fore feet; and both tame and wild individuals, if frightened or suspicious, will sometimes bite in defence of their young, or even occasionally[1] otherwise. As a rule, however, they seem to be unaware of their undoubted power in this respect, perhaps on account of the overpowering fright from which the poor things suffer when captured. The old bucks bite each other a good deal when fighting, as their ears are frequently torn, and the wounds look as if made by their teeth. At the commencement of a battle they lay the ears back like an angry horse, but afterwards as they bound and kick they keep them erect or move them much about.[2]

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[1] As in gorse in the Isle of Man (Kermode); and, for other instances, see W. W. Southam, *Field*, 2nd December 1876, 656, and Harting, *Zoologist*, 1877, 18 (same instance); John Cordeaux, *Field*, 9th December 1876, 692; A. C. Spence, *Zoologist*, 1894, 458; D. Coles, *Field*, 7th October 1899, 580; R. Service, *Ann. Scott. Nat. Hist.*, 1904, 66; J. M. Bolton, *Field*, 12th September 1908, 514; A. J. Steel, *Field*, 21st August 1909, 377; William Evans.

[2] *Field*, 16th December 1876, 726.

[3] Kearton, *With Nature and a Camera*, 1898, 180.

[4] *Op. cit.*, 20.

[5] See Harting, *op. cit.*, 19-21; and there are numerous other records.

[6] *Field*, 4th September 1897, 393.

As soon as the young are old enough to wander, the nesting burrow is deserted (about the 21st day at Kilmanock), and mother and offspring go their own ways, taking up their abode elsewhere. If suitable burrows are available close at hand they do not wander far,[3] and at Kilmanock a yellow individual has been noticed for more than a year living near the place of its birth. The old bucks are probably solitary except when breeding,[4] and are occasionally found occupying disused stops after the young have left them, but in this case a scout-hole is often added to the original stop. Mr Millais's[5] suggestion that the nesting-burrow may be enlarged and other new ones constructed around it, until it may itself become the nucleus of a small warren, may be true occasionally, but does not appear to represent the normal procedure.

Rabbits seem to be constantly practising at digging, and their wanton horseshoe-shaped scratchings, a few inches deep, may be seen in all places which they frequent, and often serve to distinguish damage done by them from the work of hares. According to Colonel Butler,[6] these abortive scratchings are invariably the work of bucks, which are naturally more restless than the does; but corroborative evidence on this point would be welcome.

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[1] Simpson, *op. cit.*, 23; Jones, *Woodcraft*, 96. I have known young bunnies in the nest to bite sharply when handled and teased on the day before they left it finally.

[2] See Charles Darwin, *The Expression of the Emotions in Man and Animals*, chap. iv.

[3] Excluding occasional, but often very marked, exceptions.

[4] There is a good account of the life of rabbits in George Abbey's *The Balance of Nature*, 1909, 227.

[5] iii., 47.

[6] Quoted by Millais, iii., 50.

Apart from instances either abnormal or based on maternal feelings, as given above, the idea of resistance to a carnivorous animal seems never to enter the animal's head. In fact, a hunted rabbit will sometimes lie down screaming, as if prevented by its fear from further attempts to escape.[1] Mr Millais[2] comments on the indifference which rabbits may display to the presence of a stoat, especially in open fields where a large company is feeding. He writes that he has twice seen a stoat pass through a number of feeding rabbits without their doing more than just lollop out of the way; but his sketch of the actions of rabbits that had been actually mauled by a stoat has met with some criticism as being imaginative.

Although not gifted with exceptional intelligence, rabbits are, nevertheless, clever enough for all the ordinary purposes of their existence, and occasionally they seem to rise higher in the scale of common sense and to almost attain to concerted action. Miss Haviland has sent me an instance of this. A patch of buckthorn bushes having been frequently beaten with dogs and the rabbits driven out and shot, the survivors suddenly discovered that they could escape by running out of the cover the moment the dogs entered it, which they accordingly made an invariable practice of doing whenever a party came to shoot.

In the articles on the hares a good deal will be found about the speed of those animals. It is also necessary to say something about the rabbit's powers of running. The numerous steps which the comparatively short legs of the animal compel it to take when going at its best speed are certainly very suggestive of pace; and although very inferior to a hare, it cannot be called deficient in this quality, as I have several times seen one by its dodging elude a smart pair of greyhounds for three or four turns. Apart from pace, the difference between a hare and a rabbit is that the latter has no wind, and, unless it gets clear away at the start, its race before dogs is invariably finished after a few twists or turns,

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[1] Owen Jones has written a graphic account of the chase and capture of a rabbit by a stoat in *A Gamekeeper's Notebook*, 1910, 237.

[2] iii., 49.

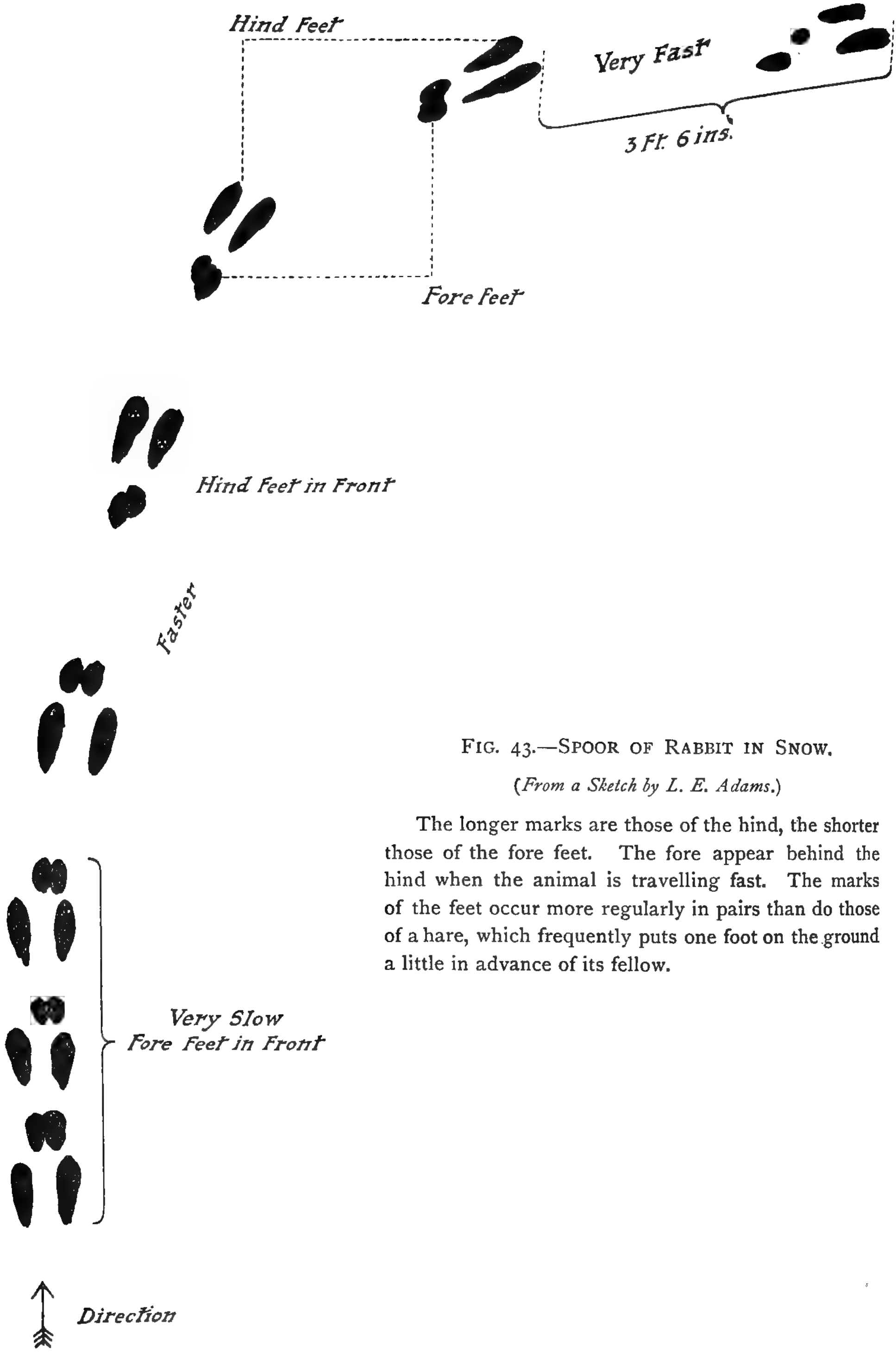
Hind Feet
Very Fast
3 Ft. 6 ins.
Fore Feet
Hind Feet in Front
Faster
Very Slow
Fore Feet in Front
Direction

FIG. 43.—SPOOR OF RABBIT IN SNOW.

(*From a Sketch by L. E. Adams.*)

The longer marks are those of the hind, the shorter those of the fore feet. The fore appear behind the hind when the animal is travelling fast. The marks of the feet occur more regularly in pairs than do those of a hare, which frequently puts one foot on the ground a little in advance of its fellow.

whereas a good hare is only then settling down into its stride. The rabbit goes off with a fine rush for a few yards, while a hare, on the contrary, reserves her strength. As Mr Allan Gordon Cameron has remarked,[1] a rabbit gets up its top speed at once, and has no spurt at a pinch, whereas a hare requires pressing, will not otherwise get properly extended, and answers splendidly to every effort of the dogs that may be almost touching it. In temperament, in fact, the two animals are widely different. The hare, confident and having no thought for a snug burrow at the end of her run, deliberately looks for her salvation to the length of the course, and is never beaten until she is in the enemy's mouth. The rabbit, designing only to effect an expeditious retreat to its burrow, loses heart if its efforts are not crowned with immediate success. If cut off from home and sorely pressed, it sometimes becomes paralysed with fear, and yields its life without further endeavour. Another point of difference is that a hare, owing to its superior size and longer stride, cares little for the nature of the ground on which it runs, and, indeed, sometimes when the going is unsuitable to greyhounds, its furry feet render it invincible. A rabbit, owing to its short legs, must have fairly good ground to run on if it is to make its best efforts. It is a poor performer across furrows, and in thick tussocky grass I have myself run down and caught one without the assistance of dogs.

Similarly, rabbits suffer a great deal when there are heavy falls of snow, the presence of which is very harmful to them. Their short legs are of little use in carrying them over the soft surface, and if they venture abroad they are easily caught. If no thaw comes in a very few days, they become emaciated, and may ultimately die, after having been reduced to feeding on the bark of trees and shrubs.

The spoor of a rabbit will be recognised from the annexed figure without further description. It resembles that of a hare, but is smaller, and the marks of the four feet at each hop fall nearer together.

The "paralysis of fear," mentioned above, may have some connection with the crouching of an outlying individual in its form until a deft kick hurls it forth into a rush for home which appears all the more vigorous by contrast with the previous inactivity. According to Mr Graham,[1] a rabbit, if alarmed on bare ground, and fearing an obstacle in the way of its homeward flight, "stretches out his legs, and lies as motionless as if he were dead"; but I have not observed this trait. Rabbits are also described as "feigning death,"[2] but that also must be the same "paralysis" in another shape, since it manifestly cannot be an advantage to a highly palatable animal that an enemy should think it dead.[3]

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[1] *Field*, 30th November 1895, 895.

The comparatively long tail of the Rabbit has been alluded to on pages 194 and 201, when comparing this animal with the hares; and anyone who watches one from behind as it moves about, cannot fail to notice the conspicuous movements of that organ[4] in what is otherwise an inconspicuous animal. It seems to bob up and down as the animal runs about, as if intended to be a kind of lure. This peculiarity was noticed by Charles Darwin,[5] who wrote of it with strict accuracy, that:—"The hare on her form is a familiar instance of concealment through colour; yet this principle partly fails in a closely allied species, the rabbit, for when running to its burrow, it is made conspicuous to the sportsman, and no doubt to all beasts of prey, by its upturned white tail." Mr Alfred Russel Wallace goes a step further, believing that the tail is a "signal flag of danger." "When disturbed or alarmed it makes for its burrow, and the white upturned tails of those in front serve as guides and signals to those more remote from home, to the young and the feeble: and thus, each following the one or two before it, all are able with the least possible delay to regain a place of comparative safety."[6] Mr Wallace's ingenious theory was hailed with much delight, and has given pleasure to many naturalists, field and closet. It has, however, been subjected to a good deal of criticism, for apart entirely from the fact that rabbits probably do not approach each other at all by sight if at any distance, it is confronted by the serious objection that the appearance of a rabbit's tail as seen by a man's eyes at a height of about five feet above the ground, must give quite a different impression to that received by another rabbit with its eyes on the side of its head, at a height of about six inches. Further, hares have similar, albeit less conspicuous, tails, yet they separate when alarmed. But there is no evading the fact that the tail is highly conspicuous, and, therefore, consciously or unconsciously, "advertising." It is clearly significant of motion, and hence, probably also of alarm, so that it may well be used as "a signal flag of danger." But that it is also a guide, or that other rabbits follow it, is highly improbable.

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[1] *Op. cit. supra*, 210.

[2] See J. R. B. Masefield, *Field*, 8th April 1911, 703.

[3] J. L. Bonhote tells me that when a rabbit is frightened its heart beats slower, which observation seems to throw light on the "paralysis" question.

[4] "The bucks carry their tails higher, so that the white shows much more conspicuously when they are moving."—Butler in Millais, iii., 50.

[5] *The Descent of Man*, ed. ii., 1889, 542.

[6] *Darwinism, etc.*, ed. ii., 1889, 218.

Another hypothesis is that of Mr Abbott H. Thayer, who has taken the trouble to view the rabbit's scut from the position of one of the beasts of prey which usually pursue it, and which are nearly all beasts of low stature—that slink and crouch, as he describes them. Seen in this way from below, the white tail becomes, according to him, a sky-matching costume, obliterating the outline of the animal carrying it. The foreshortened body is blotted out against the sky by the brightly displayed white sky-lit stern in a manner illustrated by Mr Gerald H. Thayer's[1] photographs in his father's work. The effect is, according to Mr Thayer, especially at night, to blur the outline of the animal as seen by a carnivore, so that the latter's aim is marred as it leaps at its prey. In cases of complete illusion the hunted beast vanishes into air, as it were, before the carnivore can get its aim for a leap, or even before it can perceive the direction of the quarry's flight. The tail seems, however, not to be carried sufficiently high on the back to comply with the needs of the Thayerian hypothesis, and, indeed, the absurdity of the position taken up by its ingenious author has been amply demonstrated by Mr Theodore Roosevelt.[2]

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[1] *Concealing Coloration in the Animal Kingdom*, 1909, 152-153. It should be remembered that in writing of "rabbits," American zoologists, unless they specially state the contrary, refer to "hares." But this fact does not in this case affect the argument, since everything that applies to the tail of a hare is applicable, and even more so, to that of a rabbit, in which the advertising (or, according to Thayerian interpretation, obliterative qualities) are developed to an extreme extent.

[2] "Revealing and Concealing Coloration in Birds and Mammals," in *Bull. Amer. Mus. Nat. Hist.*, xxx., art. viii., 119, etc., 23rd August 1911; noticed by J. A. Allen, *The Auk*, xxviii., 4th October 1911, 472-480.

Neither of the foregoing hypotheses takes into account the shortening of the tail which has taken place throughout the whole sub-order of duplicident rodents, and which has, no doubt, been brought about for important structural and physiological reasons. Viewed in this light, the longer tail of the Rabbit seems to be a natural characteristic of an animal less highly specialised than the hares.

Like hares, rabbits can swim, but have fewer opportunities of taking to the water. In an extreme case, a bewildered bunny has been known, in its confusion, to plunge into the sea. Mr Millais has sketched one swimming,[1] and remarks that "The rabbit is the same as the hare . . . the whole of the rump and tail is above water, while the hocks of the hind legs appear above the surface as he takes each fresh stroke." This is not, however, my experience, being rather that the *Leporidæ* swim easily enough, carrying the whole body under water except the head; the ears are laid well back, as in rapid running. The animal gives one an impression that it is trying to hide itself by keeping its body low in the water; and this is undoubtedly the case when it has been long enough immersed to become thoroughly wet. While any of its fur remains dry, it swims in the manner indicated by Mr Millais, and the discrepancy is thus explained.

Thoroughly terrestrial on all ordinary occasions, rabbits are sometimes found ascending trees to a height of ten or twelve feet, where the boughs or ivy are thick, or the trunk sloping.[2] Many such instances have come under notice, and, indeed, the activity of the animal often affords subject for wonder, as when one "runs" up a wall as high as a man's head; and when one escapes from its pursuers by climbing up the ivy on a wall, and jumping clear on the other side. Probably the most striking instance of one "nesting" in a tree is related by Mr G. C. Vassall,[3] who was shown a litter of young in a hollow branch at a height of about eight feet from the ground. The

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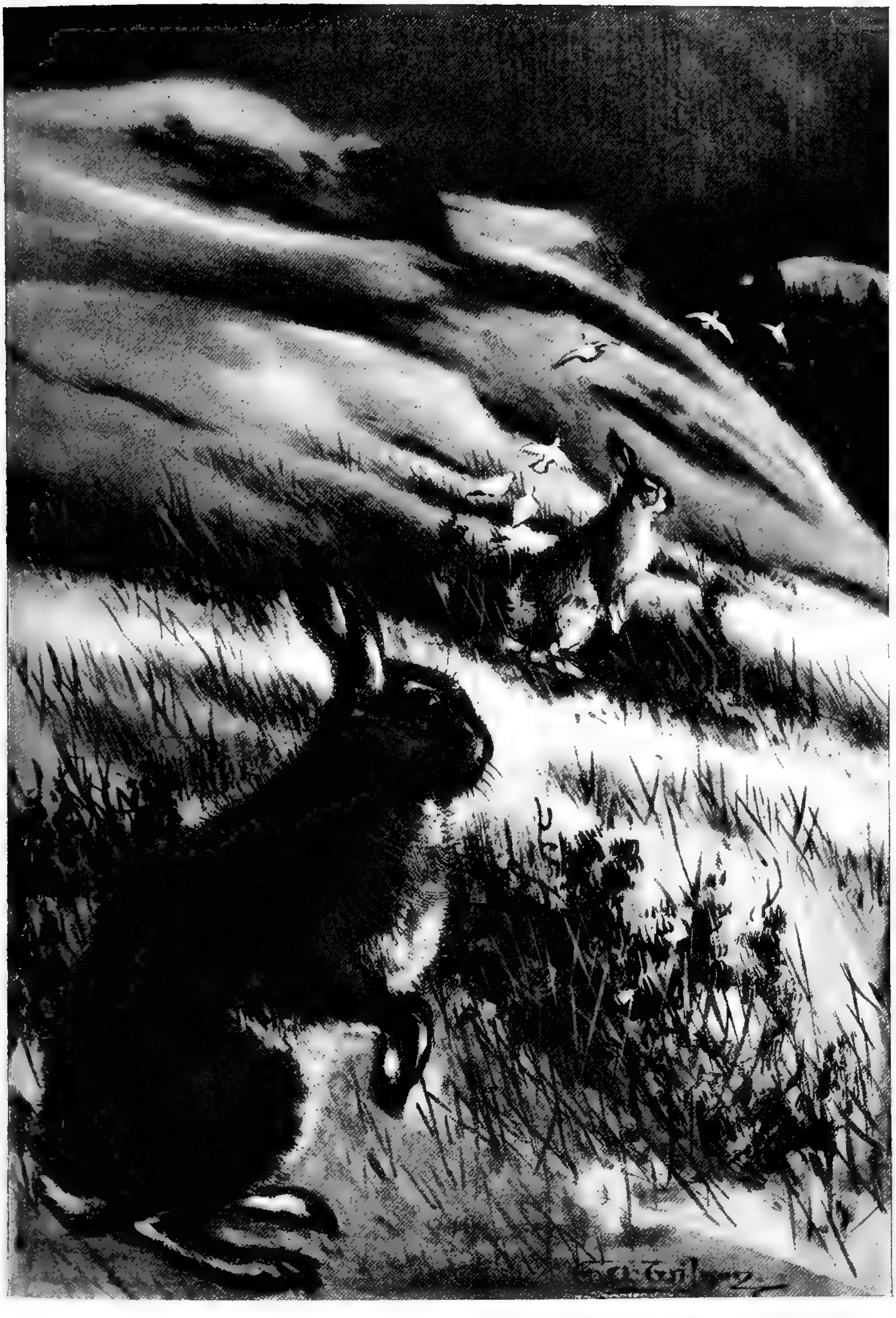
[1] *British Deer and their Horns*, 1897, 44. See also editor, *Field*, 14th May 1898, 712; C. L. Eastlake, also H. J. Grierson, *Field*, 14th January 1899, 62; R. Lydekker, *The Royal Natural History*, 1894, iii., 198; and other references.

[2] See Harting, *op. cit.*, 27; J. Halifax, *Field*, 28th January, 1899, 134. The rabbits imported into Australia are reported to have acquired the power of tree-climbing.

[3] *Field*, 5th June 1909, 983.

PLATE XV



SCOTTISH BLUE HARE.

existence of nests in hollow trees, several of which were known to Alston,[1] seems to be a corollary of the animal's love of burrowing amongst the roots of trees.

The food of rabbits may be dismissed in a very few words, since, although thriving best on rich pastures, they will eat a large variety of vegetable substances, from leaves to tubers and roots,[2] and in winter, if more palatable food is scarce, they are very destructive to the bark of most trees. In the hot summer of 1911 my keeper, M. Parle, found their stomachs full of blackberries; and according to Mr Simpson,[3] furze, and also acorns, form excellent fodder for them, and he states that they grow very fat if fed on acorns. Rabbits are commonly believed not to drink in the wild state, but Mr Cocks has seen fully a hundred drinking simultaneously at the pond at Swinley, in Windsor Forest, where the soil is dry and sandy. They soon learn to lap milk in captivity, and should always be kept supplied with water when about to kindle.

Only two instances are known to me of wild rabbits deserting their habitual vegetarianism. Thus Mr Adams states[4] that he has constantly found heaps of gnawed empty snail-shells at the mouths of burrows in the north of Ireland. On the sandhills at Portrush, these heaps often amounted to a bushel, and sometimes nearly blocked up the entrances to the burrows. He never actually observed the animals eating the snails, but concluded that the work could not have been that of rats, and that the molluscs must have been brought in one by one by the rabbits to be eaten at leisure. The truth of Mr Adams's surmise has since been confirmed beyond all doubt by Mr C. E. Wright,[5] who was able to watch rabbits eating snails in County Donegal.

When food is plentiful near their burrows, rabbits do not stray far away, and their life is one of more or less regular routine. They feed for the most part during the afternoon,[6] evening, and night,[1] and in the morning rest within the shelter of the burrows, play, or bask in the sun.[2] In feeding, they at first advance slowly and cautiously from the burrow to the edge of the covert; then, if they have a distance to travel, they break into a rush at the end. Passing over the same ground day after day, they consume the vegetation near them in succession, clearing a space around their burrows and sometimes cropping one side of a field bare, while, perhaps, the remainder of it is untouched. Their depredations on grass or growing corn are thus, unlike those of hares, confined in normal conditions to definite areas. When food is scarce, as when snow lies on the ground, or on poor pastures, they keep on the feed more continuously, and will wander a long way to a turnip field, or to bark trees in a plantation. In the spring, too, the sexual season causes many of them to seek new ground, and the places of those killed off in pleasure-grounds or other forbidden fields are soon filled by newcomers. Occasionally their routine is upset even where food is plentiful, for they are believed to graze voraciously before a storm in summer, and when the grass is wet are not observed so much abroad.

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[1] *Bell*, ed. ii., 345.

[2] W. P. Westell (*The Young Naturalist*, 1909, 114) suggests that in spring rabbits nip off portions of the flowers of primroses in the woods out of sheer mischief.

[3] *Op. cit.*, 73; *Field*, 9th December 1893, 896.

[4] *Quart. Journ. Conchology*, vol. xii., 268, April 1909.

[5] *Journ. et loc. cit.*

[6] Arthur Willey (*Convergence in Evolution*, 1911, 29) cites the Rabbit as a rare instance of the combination of fossorial and diurnal habits. Very many burrowing mammals are certainly nocturnal, but there are numerous exceptions, as, for instance,

The tastes of rabbits and hares in trees have been somewhat extensively treated by Messrs Simpson and Harting in their respective works, as well as by Mr Abbey,[3] who points out that, unlike hares, which always nibble, gnaw, and peel above the snow line, rabbits take up their abode in the "caves" formed by snow overlying evergreens, where they feed on the stems. Miss Haviland has rightly drawn my attention to the fact that in the south-east of Ireland, where the winters are rarely severe, rabbits nevertheless bark trees, and she suggests that the astringent bark of ash, blackthorn, laurel, and ivy are valuable as counteracting the action of the sodden half-decayed grass on which they are driven to exist for so many months of the year. She believes that the roots of the wild iris or yellow flag are eaten for the same purpose. Miss Haviland[4] has observed that in some

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more than one species of "mouse" in Britain, and many burrowers living on open plains, as ground squirrels, prairie dogs, golden "meerkats" (*Cynictis*), and others.

[1] But they may be changed from nocturnal into diurnal feeders by a regular course of disturbance at night—see Jones, *A Gamekeeper's Notebook*, 219.

[2] Simpson, *op. cit.*, 68-73. [3] *Op. cit.*, 101-102. [4] *Op. cit.*, 117.

Irish woods a particular tree is barked by rabbits in such a way as to suggest that their object was other than to seek food.

The white flesh, so distinct from the brown meat of the hares, attracted the attention of Herbert Spencer,[1] who connected the differences between the white and red muscles with the relative activity of the two animals. According to Spencer, birds and mammals show greater endurance along with the darker coloured muscles; and, with the same result, he compared the flesh of old and young animals, veal and beef, lamb and mutton, and the flesh of different parts of the same animal, as the leg- and pectoral-muscles of so many birds, such as turkeys, guinea-fowls, and pheasants.[2]

The scream of a frightened or wounded rabbit is well known to dwellers in the country. It is pitched so high in the very young as to remind one of the shrill cry of a bat. But there are also some peculiar grunting sounds, some of which have been mentioned above. They are somewhat difficult to express in words, since, although distinctly grunts, there is a just perceptible element of shrillness in them. A buck in the spring will approach another rabbit, stamping its hind feet at intervals; as it gets nearer, it begins to grunt frequently and very audibly, and eventually one, generally the second rabbit, retreats, and is chased by the other. In a note by an anonymous writer,[3] the grunts are said to be the common property of both tame and wild rabbits, and the action is likened to a hiccough, or to the word "huck" in the throat, without moving the lips; the flanks alone move. The grunt, which is a sound of pleasure, may be rapidly repeated; it may be "a single enquiring grunt" or "a single long-drawn sighing grunt." The latter is accompanied by an impatient stamp of the hind feet, a characteristic method of expressing the feelings that seems to be a useful supplement to the grunts, especially in the resonant burrows. Anger is expressed by a low growl. The writer quoted believes the grunt to be confined to adults, but it has been shown on p. 217 that this is not correct. Anyhow, rabbits, especially bucks, can be called and shot by a sound similar to that used for calling hares, and the Scots have a special name, "map," for a rabbit-call;[1] indeed, calling rabbits in order to shoot them is a common practice, but it is difficult to decide what is the motive of the called rabbit—curiosity, sociability, or anger. A rabbit, like many small birds, will approach, usually with many stamps, to investigate a very clumsy calling that has no effect on hares other than to make them shake their ears and remain still listening, and Mr Cocks has known one to reconnoitre him in this way on a dark night in a wood.

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[1] *Principles of Biology*, revised edition, 1889 (vol. ii.), 365

[2] Spencer's generalisation will not stand examination. Dark-fleshed birds, like the ptarmigans of Spitzbergen and Alaska, are very inactive—much more so than the pheasant and partridge, which are, the former partially, the latter wholly, white-fleshed.

[3] B. P., *Field*, 11th March 1905, 414, a note which must be quoted, although anonymous, in default of a better.

The greater attractiveness of one or other of the domestic breeds of rabbits is such that few people take the trouble to tame a wild one. But the latter, although, if adult, rarely losing its "wildness" after capture, will, if taken young, well repay the attention bestowed on it, and more than one thus brought up by hand has lived for years in honour and happiness. At least two such are said to have been alive and well in their eleventh year, another reached upwards of thirteen,[2] and there are records of others which lived for long periods. Like hares, they are, if left at large in a house, boisterous, noisy creatures, and too active and playful to become altogether satisfactory pets.

Domesticated rabbits are often turned out in coverts "to improve the breed" of the wild ones, especially in regard to size. This result is obtained at the expense of much of the alert liveliness of the true wild animal, but the most conspicuous effect is usually the appearance of a number of abnormally coloured individuals. Miss Haviland has noted that where such varieties are white they do not seem to be killed off by foxes, as might be expected from their conspicuousness, and she suggests that foxes may be frightened by their unusual colour.

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[1] See above, p. 180.

[2] One lived at least six years, Blanche H. Cripps, *Field*, 16th July 1892, 85; eleven years, H. A. Macpherson, *Zoologist*, 1883, 173; one born 1887, alive 10th January 1898, *fide* F. Moekler, *in lit.*, to Oldfield Thomas; white buck, upwards of thirteen years, J. W. M. Dagnall, *Field*, 26th November 1887, 822.

GENUS LEPUS.

1758. LEPUS, Carolus Linnæus, *Systema Naturæ*, x., 57 ; xii., 77, 1766 (part) ; based on *L. timidus* of Linnæus—type (see Thomas, *Proc. Zool. Soc.*, London, 1911, 145, published March 1911), and *L. cuniculus* of Linnæus, both from Europe, *L. capensis* of Linnæus from the Cape of Good Hope, and *L. brasiliensis* of Linnæus from Brazil.

1829. CHIONABATES, Jakob Kaup, *Europäische Thierwelt*, i., 170 ; based on *variabilis* and *borealis*.

1867. EULAGOS, J. E. Gray, *Ann. and Mag. Nat. Hist.*, September, 222 ; based on *Lepus mediterraneus* of Wagner, and *Eulagos judeæ* of Gray, "The Holy Land Buneas, Tristram."

1899. EULEPUS, Alex. Acloque, *Faune de France*, *Mammifères*, 52 ; based on *europæus* and *variabilis*.

1904. PŒCILOLAGUS (sub-genus), M. W. Lyon, jr., *Smithsonian Misc. Collections*, 395, 15th June ; based on *Lepus americanus* of Erxleben, *L. bishopi* of Allen, *L. klamathensis* of Merriam, *L. saliens* of Osgood, and *L. washingtonii* of Baird.

The **synonymy** is simple.

Hares are probably of American **origin**, since they appear first in the upper Oligocene of North America. In Europe and Asia they are not known earlier than the lower Pliocene.

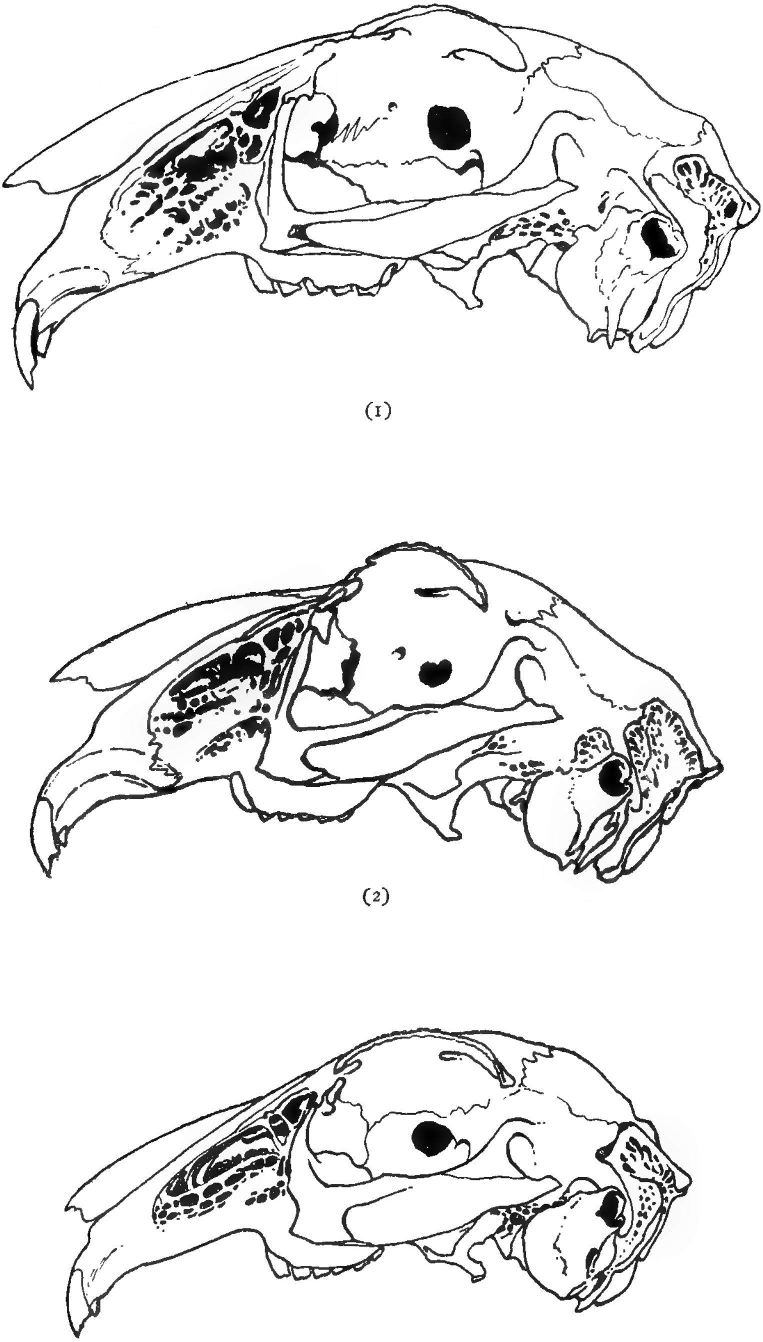
They are widely **distributed** in North America, Asia, and Africa in tropical, temperate, and arctic regions.

They form a very natural assemblage of leporide rodents, which rest in "forms" in grass or bushes and do not usually burrow. In escaping from their numerous enemies they rely on their speed and activity, or their power to shake off their pursuers by resorting to thick coverts. Even when partially gregarious or sociable in their feeding habits, as they sometimes are, they separate if chased, and rejoin each other by means of their very efficient olfactory apparatus, no doubt helped by the secretions of their inguinal glands.

The **young** are born in a high state of development, fully haired, and with their eyes open.

The **flesh** of adults cooks dark and resembles venison ; it is much lighter in leverets.

Characters :—Hares have the **body** light ; the head thick ; the ears long ; the eyes large, prominent, placed on the sides of the head and with slightly elliptical pupils ; the insides of the cheeks hairy ; the nostrils circular, and connected by a fold with the cleft upper lip. The slender limbs are of uneven



(3)

FIG. 44.—SKULLS OF (1) *Lepus europæus;* (2) *L. timidus scoticus;* (3) *Oryctolagus cuniculus.* (All life size.)

length, the hinder being conspicuously large and strong, and with four digits; the shorter fore limbs have five. The tail is always present, but is short and recurved. The soft fur is, as described above (p. 162), composed of three kinds of hairs; it is so dense on the soles of the feet as almost to hide the claws.

The intestine is long, with a large cæcum.

The **skull** is strongly arched, and distinguishable from that of other allied genera by its breadth, which shows itself specially in the brain-case, rostrum, and nasals, the two latter being also short. There are no alisphenoid canals.

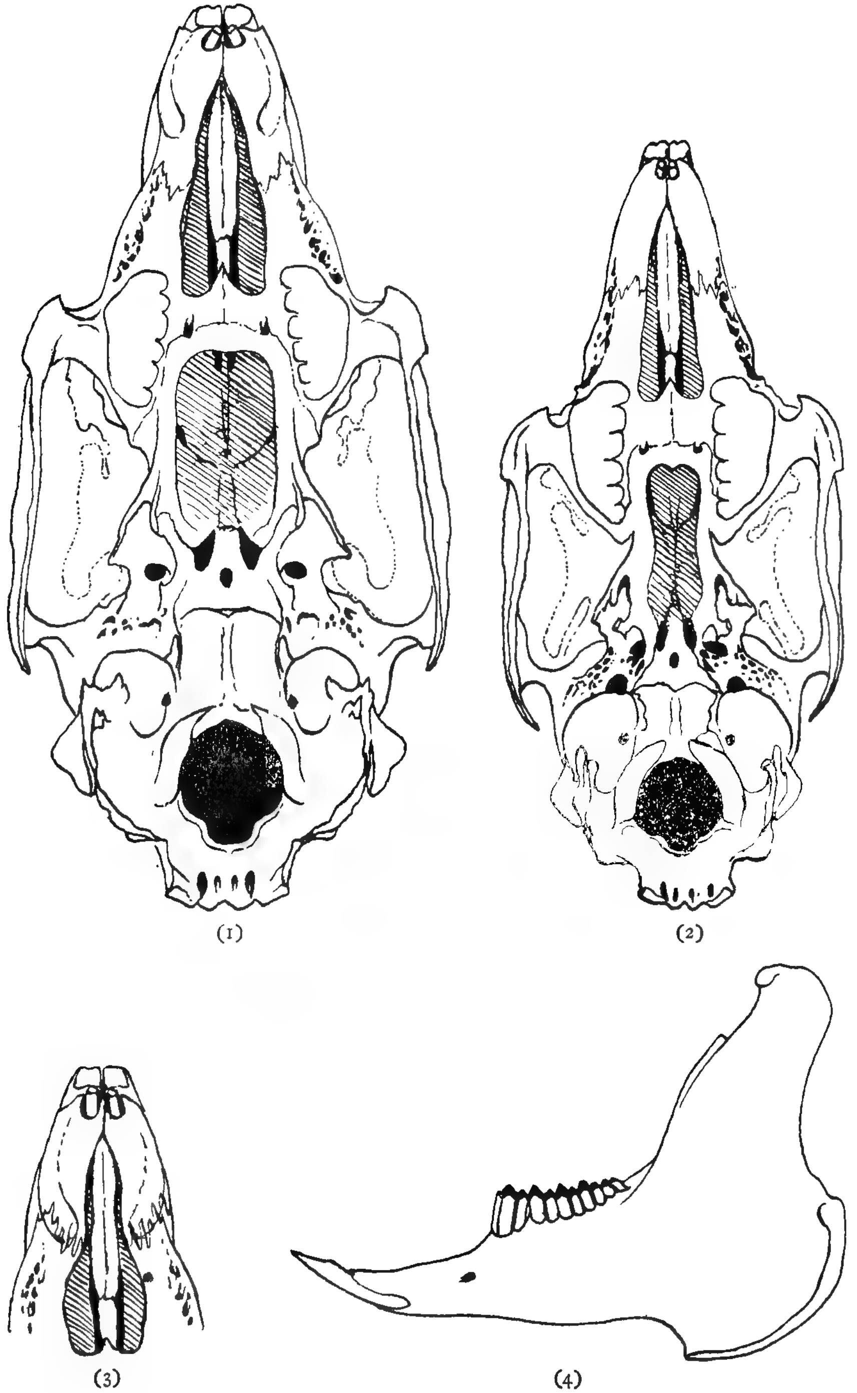
The superciliary processes of the frontals are well developed as large, wide, triangular structures, with one angle attached to the skull, and the other two usually quite free. They stand out from the side of the head, and are considerably arched from before backwards. Between the free angles and the skull there are usually large notches, the posterior being the larger; but occasionally an angle may be so directed inwards that its apex meets the frontal bone and forms a foramen instead of a notch.

The interparietal bone, although present in the very young, becomes obliterated in the adult (see Fig. 33, p. 174).

The bony palate is short, and reduced to a mere narrow bridge with its transverse breadth greater than its least antero-posterior length; the length is distinctly less than the width of either the posterior nares or the coalesced incisive foramina, both of which form wide apertures. About four-fifths of the palatal bridge are formed by the maxillaries, and only one-fifth by the palatine bones.

The sides of the maxillary bones are fenestrated.

The zygomatic arches are well developed, deep but thin, and are thickened anteriorly so as to form massive buttresses projecting at right angles from the maxillary walls. Each is composed chiefly of the malar bone, which, however, fuses at an early age with a small zygomatic process of its maxilla, of which it afterwards has the appearance of being a long backwardly directed process, with its extremity projecting behind and below the zygomatic process of the squamosal. The latter is a triangular, foot-like structure carried on a narrow stalk; it articulates with the malar by means of a suture, which persists through life, and is only about half the length of the



(1) (2)

(3) (4)

FIG. 45.—SKULLS OF (1) *Lepus europæus;* (2) *Oryctolagus cuniculus;* and (3) PALATE OF *Lepus timidus scoticus* (all viewed from beneath, and 1¼ times natural size). (4) MANDIBLE OF *Lepus*.

superior border of the malar, when the latter is measured from the anterior end of the squamoso-malar suture to the antero-inferior angle of the orbit.

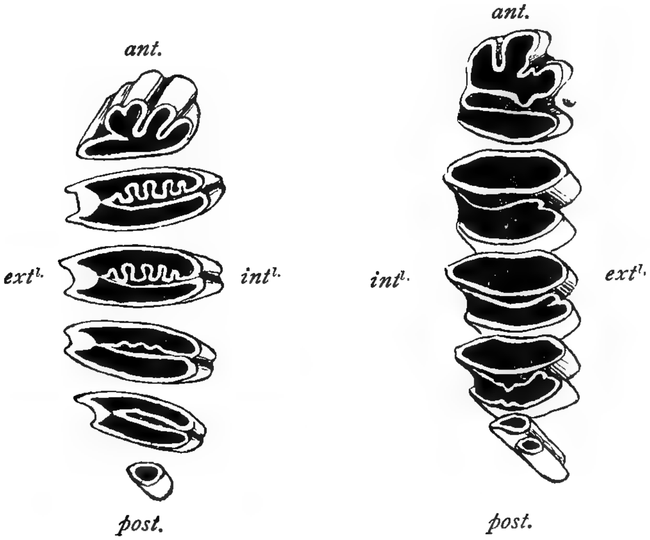
The external auditory meati are prolonged upwards and backwards into tubular structures, which, combined with the bullæ, resemble flasks.

The angular and condyloid processes of the mandibles are much developed; the coronoid processes nearly absent. The mental foramina are small, and lie well in front of the cheek-teeth.

There are thirty **teeth** at birth; soon afterwards a pair of upper incisors is lost, and a little later the three anterior upper and the two anterior lower cheek-teeth are shed and are replaced by their permanent successors. Thus the adult dentition comprises twenty-eight teeth, of which the arrangement is—

$$i\,\frac{2-2}{1-1},\quad c\,\frac{0}{0},\quad pm\,\frac{3-3}{2-2},\quad m\,\frac{3-3}{3-3} = 28.$$

The large upper incisors have each a groove, often filled with cement, running vertically along their anterior surfaces. (Fig. 34, p. 175.) The courses of their roots are plainly visible externally.



Upper. Lower.

FIG. 46.—CHEEK-TEETH OF *Lepus*, diagrammatic and magnified.

The permanent cheek-teeth are without roots, so that they grow throughout life. They have the appearance of cylinders, not circular, but broadest transversely, and filled with dentine. The first upper premolar has on its anterior face at least three enamel, cement-filled foldings, of which the central one is deep, the two outer shallower. The second, third, fourth, and fifth teeth have each, on the inner side, a single deep re-entrant enamel fold, extending about three-quarters of the distance across the tooth ; its sides are nearly in contact, and more or less crenated. The enamel lines the sides of the transverse folds, and completely invests the internal faces of the teeth ; externally it has atrophied, so that the outer faces of the teeth are formed in great measure of bare dentine. For an account of the evolution of this structure, see above, under *Ochotonidæ*, pp. 156-158. The last upper molar is a small, greatly reduced tooth, elliptical in section and quite simple in structure.

The lower cheek-teeth are framed on the same plan as the upper, but in these the enamel is infolded to a much greater extent, so that they are divided into two portions, an anterior and a posterior, by a single transverse fold from the outer side. In accordance also with the well-known principle, that the inner side of an upper corresponds with the outer side of a lower grinder, and *vice versâ*, the enamel is developed continuously on the outer, and atrophies on the inner sides. The anterior portion of the first grinder (*pm* $\overline{3}$) has a small re-entrant angle on its anterior face, and a broader one on its outer side. The second, third, and fourth have their posterior portions with lateral diameters about four-fifths of those of the anterior portions. The last is small, and resembles a double cylinder with a larger elliptical anterior and a smaller separate rotund posterior portion.

The mandibular tooth-rows lie so much closer to each other than those of the maxillaries that only the teeth of one side are capable of opposition at the same time, and the jaws have consequently a lateral motion in mastication.

In the **skeleton** the cervical vertebræ are uniformly lengthened, the transverse processes do not project laterally from their centra to a marked extent, and the anterior and posterior spines are comparatively elongated.

The lumbar vertebræ have wide and long transverse processes with expanded extremities, which arise abruptly from the anterior half of their centrum. Those of the fifth are the longest of the series; and each has a length equal to that of its centrum, plus half the length of the centrum just anterior to it.

There are thirteen to fourteen caudal vertebræ.

The ribs have the spine-like portions of the tubercles well developed, the last pair bearing these tubercles being the eighth. The second, third, fourth, fifth, and sixth pairs have the ventral halves of their shafts very flat and broad, so that the greatest width of one of these ribs, just behind the tubercle, is very much less than the width of the shaft in its lower portion. Seven pairs of ribs articulate with the sternum. The sterno-costal cartilages are very short and wide as compared with those of *Oryctolagus*.

The clavicles are imperfect, as throughout the family (see above, p. 159).

The scapulæ are relatively broad with their superior borders relatively convex, the antero-superior angles relatively rounded, and the supra-spinous fossæ relatively broad.

The ulnæ are reduced in size along the centres of their shafts, and, except at their lower extremities, lie almost entirely behind the radii, which latter are rather long and slender, and in length may equal or exceed their humeri.

The fibulæ are ankylosed to the tibiæ.

In some exotic species the lengthening of the external **ears** has been carried to such an extraordinary degree as to have inspired the belief that these organs could not have been developed solely for purposes of hearing. So good a field naturalist as Thompson Seton can imagine no better use for them, in the North American *Lepus campestris*, than as a possible shelter to the back of the animal as it sits in its form during heavy rains; and, more than two thousand years ago, the celebrated Greek soldier and sportsman Xenophon (born about B.C. 430), in a treatise on hare-hunting entitled *Cynegeticus*, supposed that, since the tail is so short as to be useless for steering purposes at high speed, an ear on one side might be laid down and thus assist in turning the body when sharply pursued. Modern coursers have also noticed this movement, and say that a hare when coursed and hard pressed by greyhounds, turns down the ear on the side to which she is going to turn, and that she does this in order the better to catch the sound of her closest pursuer, so that she may turn away from him, for she rarely turns so as to favour the dog that is not leading.

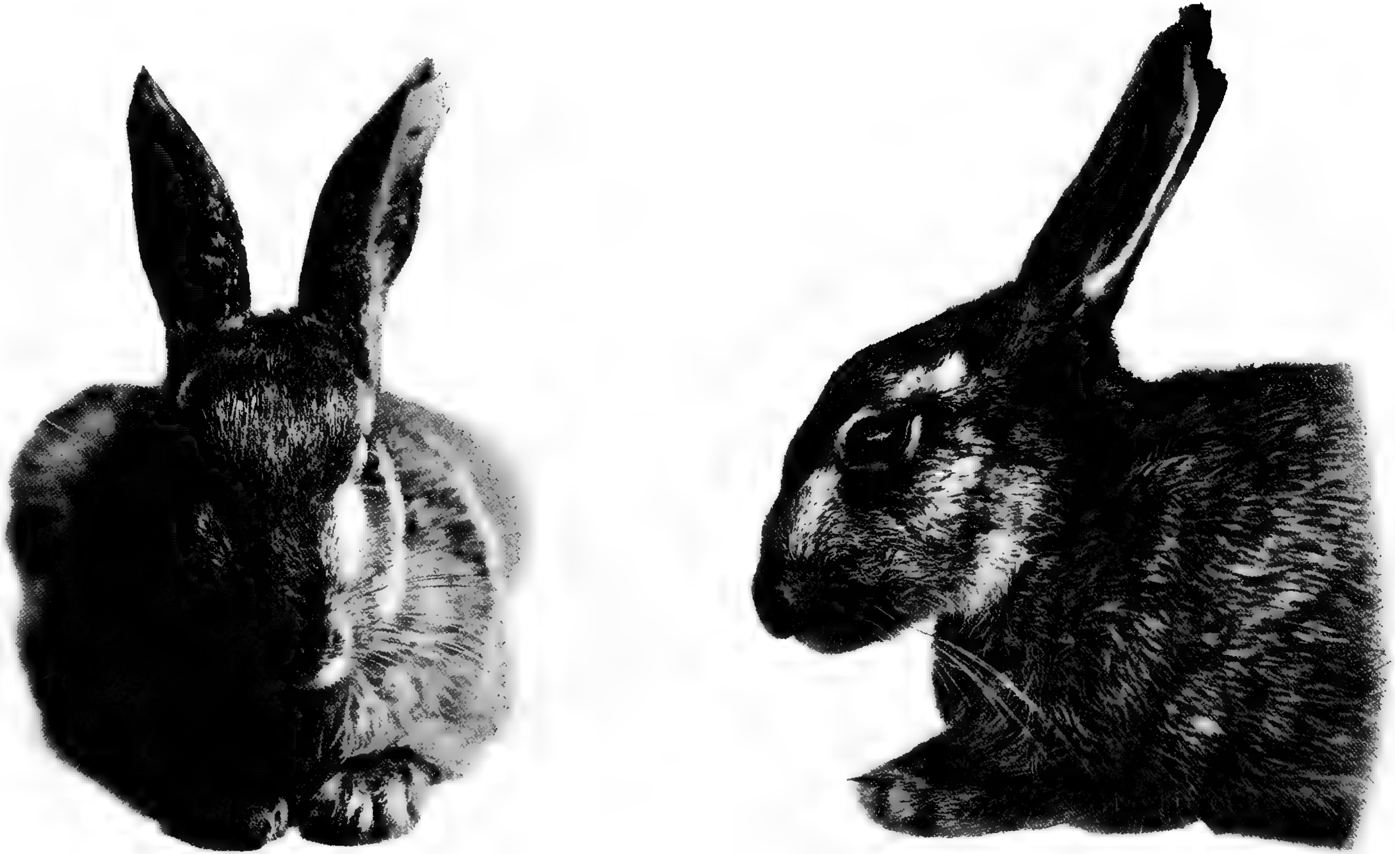
If Xenophon's supposition were correct, it might be argued that the long ears are correlated with the short tail, now so much reduced as to be useless for steering purposes. Winge has, however, suggested (*Jordfundne og nulevende Gnavere*, 1888, 112) that the correlation is between the tail and the legs. As in the fast ungulates, so in *Lepus*, the limbs have become so powerful and so completely specialised for purposes of speed that they have taken over the whole business of steering in addition to that of supporting the body. The tail has accordingly no work left to do, and it consequently tends to disappear. It is superfluous as a counterpoise, and, as it is not required as a fly-flapper, it becomes reduced to a mere stump, and the body itself acts as its own steering organ, through the strong flexor and extensor muscles of the modified vertebral column acting on the extended or flexed body.

In any case, the short scut would seem to be almost a necessity for animals which are being constantly chased, since a long tail would place them more readily at the mercy of their pursuers. Short as is the scut, I have seen a greyhound "chop" it off an Irish Hare which itself escaped for the moment.

Apart from any other considerations, extremely long ears undoubtedly indicate acute powers of hearing, probably in compensation for comparatively indifferent sight, and they point also to their possessors being of nocturnal habits.

Droppings :—These are similar to those of *Oryctolagus*, but larger, and their greatest diameter may reach about 20 mm. They are somewhat flattened pellets of very uneven diameter, dry in texture, dark in colour, and having a strong characteristic odour.

Hybridism :—For many years field naturalists and sportsmen have from time to time reported the occurrence of hybrids between *L. europæus* and *L. timidus*, but until exact methods of studying animals became adopted of late years, all such statements were looked upon with suspicion by workers in museums, who, in fact, were not at the time aware of any accurate mode of distinguishing the hybrids. Latterly, the



HEAD OF BRITISH BROWN HARE (*Lepus europæus occidentalis*), Female.

characters of the two animals, both external and internal, have become known with so much greater precision that a reputed hybrid receives a more satisfactory examination than was possible until quite recent years. But at the best it must be confessed that such specimens, as might be expected, are extremely like one or other of their parents, and are consequently difficult to distinguish. Nevertheless, sceptical as the scientific mind has undoubtedly been in the past, the general attitude must be regarded as having recently undergone considerable change, and has now become one of acquiescence. The frequent introductions by sportsmen of one or other species of hare into the territories of the other (for details of which see the articles on the species), with the repeated assertions of competent field naturalists like the late John Cordeaux that such interbreeding occurs (see Cordeaux, *Field*, 23rd September 1876, 362; McNichol and Colquhoun, *Field*, 7th October 1876, 434; Lumsden, *Zoologist*, 1877, 101; Harting, *Proc. Linn. Soc.*, London, 1897, 4, and *Field*, 6th May 1905, 762), and finally, the statement by Lönnberg that in southern Sweden, owing to the introduction of the Brown Hare for sporting purposes, hybrids have become comparatively common, have all largely influenced the change. Such hybrids have also been reported from other European countries, as from Russia by Middendorff, from Switzerland, and from Livonia (see Lönnberg, *Proc. Zool. Soc.*, London, 18th April 1905, 278-87). It is certain that, although the Blue Hare as a species retreats before its larger relative, there is no active antagonism between the individuals of either. Where their ranges overlap the two meet naturally and interbreed, and Millais (iii., 24; also *Field*, 18th February 1911, 330) has killed an equal number of both species in a day's shooting at Murthly, Perthshire, and has often seen them rise from their forms close to one another. According to Millais, after severe winters in Perthshire, such as occurred in 1865, 1881, and 1894, large numbers of Mountain Hares descended to the low moors, and to the moorwoods bordering the rivers Tay and Earn, where they stayed on through several summers until they either were shot or wandered back to their proper habitat. During these visitations they mixed indiscriminately with the Brown Hares, and undoubtedly several crosses resulted; and Millais states that he himself once shot no fewer than six of the hybrids. In Sweden the actual pairing of the Brown and Blue Hares has been observed by sportsmen, and Lönnberg has described the resulting hybrids, which are stated to be numerous, and perhaps fertile when interbreeding amongst themselves. They are, however, most plentiful immediately after an introduction of Brown Hares into the territory of the Blue, the first meeting of the two species—the current belief that they are antagonistic notwithstanding—seeming to lead to irregular alliances. As they become accustomed to each other, hybridism decreases.

In spite of what has been written above, most of the specimens reported as hybrids are either large Blue Hares, or Brown Hares in the grey pelage. A few, however, show characters intermediate between the two species, and are, therefore to be regarded as correctly named. There are three such in the British Museum of Natural History, all from Scotland, viz., No. 63.8.23.1, an old skin from Inverness; No. 2.11.28.1, a male from Craigmyle, Aberdeen; and No. 6.12.26.1, a male from Capernoch, Thornhill, Dumfries. In all three the ear is longer than in the Blue Hare, the colour pattern similar to but less distinct than that of the Brown Hare, and the tail short as in the Blue, but with a central black dorsal area as in the Brown. Harvie-Brown has also recently forwarded two specimens, of which the characters, both external and cranial, appear to indicate hybridity.

The much more improbable **interbreeding of hares and rabbits** has been even more frequently reported, especially on the Continent, and the credence which such reports have received may have been due to the inducements offered by the numbers of people who are willing to pay a high price for a "leporide." Although "Leporides" are mentioned by Charles Darwin (*Animals and Plants under Domestication*, 1868, i., 105) in one of his arguments, and actually received the technical name of *Lepus darwinii* from Haeckel (*Hist. de la Création des êtres organisés*, 1874, 131), no proof has yet been advanced that two such naturally antipathetic animals, having such diverse structure, habits, glandular secretions and odours, and such entirely different young, have ever united and produced offspring.

So long as rabbits are commonly kept in captivity for purposes of pleasure or profit, reports of their successful hybridisation with hares will probably continue to be advanced by those who have not sufficiently considered the difficulties of the subject. Zoologists will continue to accept such statements with caution;[1] and field naturalists are unanimous that the animals are naturally antipathetic, and will not even thrive well together on the same ground. This may be, as Woodruffe-Peacocke suggests (*The Cultivation of the Common Hare*, 1905, 11), because rabbits, when in numbers, bully, chase,[2] and worry hares to death, or, perhaps, because the rabbits eat or taint the food of the more delicately feeding hares, or because the former infect the latter with epidemics to which they are themselves immune. A particularly vicious attack by a rabbit was described by E. T. Booth (*Field*, 6th Oct. 1883, 490); the hare was bitten on the hind quarters and gave vent to repeated screams.

The literature of this subject runs through many languages, and is very voluminous. But, since it proves nothing, it may safely be neglected. Its character may be sufficiently indicated by the following sentence, selected from Simpson (*The Wild Rabbit*, 1908, 82), an otherwise sane writer, to whose work, as stated above on p. 202, indebtedness has been gladly acknowledged:—"The Belgian hare is a hybrid between the hare and the rabbit, and as such has been a puzzle to naturalists, because it is almost the only hybrid that is fertile and can perpetuate its kind."

Hares have been the subject of so many **superstitions** in so many lands, that it would be impossible to mention more than a few of the more striking.

There was a hare-god in Egypt from very early times, dating, with the frog-god, from about B.C. 4000. Although so old, it is rare, but has been figured by Wallis Budge (*Papyrus of Ani*, pls. 12 and 35; see also Lanzone, *Mittologia*, pl. 52).

As with the Mole, an anatomical misinterpretation doubtless led to the remarkable idea that the sex is frequently **changed**; which may be compared with the "widespread African belief that hyænas are bisexual, being male or female as they choose" (Roosevelt, *African Game Trails*, 1910, 329). This error appears in writers of different periods, and is said to have survived until the end of the eighteenth century.[1] Amongst others, Pliny repeated it, saying that hares are of both sexes, and that the female can bear young without the male; and in the Gwentian code of north-east Wales, supposed to be of the eleventh century, the animals are said, not to be capable of any legal valuation, being in one month male and in another female. It is, therefore, not surprising that in many of the older works the masculine and feminine pronouns are indiscriminately applied to them, as was the practice of William Twici, and also of The Master of Game (see p. 247).

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[1] For a long account of Roux's experiments, see Holdsworth, *Zoologist*, 1862, 7923 and 7983. The question was well discussed by Saint Loup, *Rev. Sci. Nat. appliquées*, Paris, Nos. 1 and 2, 1-15, and 49-59, 5th and 20th January 1893.

[2] *Cf.* "When they (*i.e.* the hares) be in their heat of love and pass any place where conies be, the most part of them will follow after her as the hounds follow after a bitch or a brache" (*The Master of Game*, ed. 1909, 22).

Hares are often regarded as beasts of ill omen, and there is a widespread belief that, if one crosses the path, the journey should be abandoned for that day. This superstition may be traced back at least to the French sporting writer du Fouilloux, who believed that a meeting with either hare or partridge when starting out in the morning to harbour a stag would be to augur a bad day's sport (*La Venerie*, v., 22). Similarly, in some parts of Scotland and Ireland (*e.g.* in Connemara, Browne, *Proc. Roy. Irish Acad.*, v., 1899, 260) the name of the hare must not be uttered in the hearing of fishermen. On the other hand, according to Millais (iii., 21), the Scottish people consider it a lucky thing when a hare starts from the last patch of grain to fall, and the animal is by them regarded as the spirit of the corn. This last portion of the harvest to be cut is called "the hare," and the man who cuts it is said to have "caught the hare." This contradictory mixture of good and evil omens seems to have descended from very ancient times, the animal having been associated with ill-luck amongst the Greeks and Indians, but with fertility of the land amongst the Friesians (Keller, *Die Antike Tierwelt*, 1909, 216).

The cleft upper lip is no doubt responsible for the popular idea that the mother of a child born with a **hare-lip** must have

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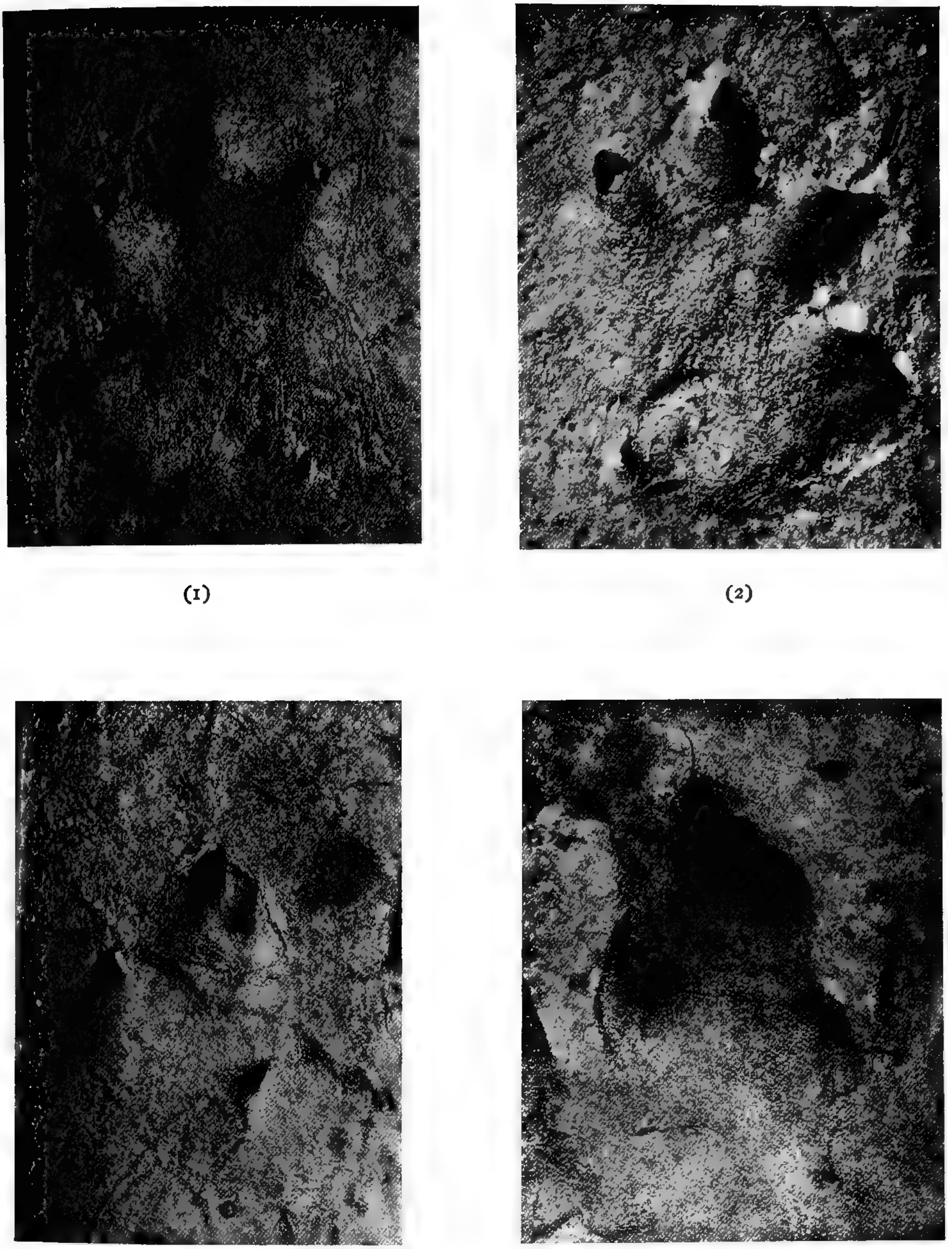
[1] *Cf.* Merriam's statement of the American *Lepus bairdii*, that all the males have teats and take part in suckling the young (6th *Ann. Rep. U.S. Geol. Survey*, 1873, 667).

PLATE XVII.



(1) (2)

(3) (4)

Spoor of Irish Hare; photographed from single footprints made by wild animals on mud in natural conditions. (1) Left fore; (2) right fore, sinking deeper in softer mud; (3) right hind; (4) right hind, sinking deeper in softer mud; both the impressions of the fore feet show all five toes well spread out to assist in turning. (Natural size.)

recently started a hare, or stepped over its form; the same superstition is prevalent in Norway, where, lest a pregnant woman should see it and like evil consequences result, a hare's nose is always cut off directly it is killed.

The **hare and** domestic **cat** are often associated either by name (as "puss") or in legends, the latter generally not to their credit, since both commonly figure as the servants or companions of witches. E. R. Alston (*Zoologist*, 1867, 921) quoted from Simrock (*Handbuch der deutschen Mythologie*, 1855, 488), to show that the saying "letting the cat out of the bag" is connected with the German superstition that you may obtain money from the devil by tying a black cat in a bag, secured by ninety-nine knots, and selling it to the fiend as a hare at a church door at midnight. But, as soon as the bargain is struck, you must fly with all haste, for, if you reach not the shelter of a Christian roof ere the fraud be discovered, you are lost for ever. The hare, like the cat, was a common form for a witch to assume, and Alston printed the charms to effect the transformation either way used by Isabel Gowdie, who was convicted of witchcraft in Nairnshire in 1662 (*Zoologist*, 1867, 977, from *Chambers's Domestic Annals of Scotland*, 1858, ii., 287).

The animal appears also in ancient **pharmacies,** and some wonderful remedies in which it plays an important part may be found in Topsel, Gervase Markham, and doubtless many other works.

There was a curious Devonshire village custom, now extinct, called the "hare-hunt," which was intended to ridicule a man who submitted to a rough woman's tongue (Baring-Gould's *Red Spider*, 1887, xxiv., in *Dial. Dict.*).

A strange fiction, that hares having no eyelids, or only very short ones, **sleep with open eyes,** was at one time very widely accepted, and still appears in the works of popular writers. Although not found in Aristotle, the belief is very ancient and runs through the works of many of the late Latin and Greek writers. Topsel had it evidently from Gesner, and Daniel repeated it in his *Rural Sports*. It may possibly be traceable to a remark of Xenophon's (*Cynegeticus*, v., 26) that there are many reasons why hares have bad sight: their eyes project, and the eyelids are not sufficiently long to protect the ball, which circumstance, added to the quantity of sleep that they take, renders the sight indistinct. A curious alternative explanation was that the eyelids are certainly closed in sleep, but are so thin as not to obscure the sight; and this legend has a certain underlying substratum of truth in the undoubted difficulty experienced in finding a hare asleep. No matter how close an approach she allows as she lies in her form, her eyes are always open. In fact even tame hares rarely become so trustful as to allow themselves to slumber with closed eyes in the presence of man. But the poet Cowper (*Gentleman's Mag.*, June 1784, 412, etc.; his epitaph on Tiney, *Journ. cit.*, December 1794, 935), and, later, Drane (*Trans. Cardiff Nat. Soc.*, xxvii., ii., 1894-95, 101-109; *Field*, 25th March 1905, 505), found that, when thoroughly docile, they close their eyes like other animals, and the pupil is then much reduced in size. Drane has opened an eyelid of a sleeping pet hare when the effect of the light was seen to cause an expansion of the pupil of the single eye even before the animal awoke. In sleep the eyes are so deeply sunk in their sockets that when closed they are level with the surrounding surface. When fully awake they project beyond it, but the extent of the protrusion varies with the will of the animal, and in the same way the extent of white conjunctiva visible may vary from a considerable amount to none at all.

Occasional reports of **horned hares** have been usually regarded as the product of a vivid imagination. They are believed to be sometimes founded on confusion with a roebuck, but more often may be perpetuated by fraud, as shown by Scherren (see *Field*, 1st and 22nd June 1907, 870 and 1063; also Yates, *Journ. cit.*, 15th June 1907, 1015), the former of whom reproduced the figure of a "horned hare" after the German Ridinger (*Vorstellung der wundersamsten Hirschen*, pl. 80). The belief in their occurrence is certainly ancient, and is found in so many old writers that it is not necessary to mention names. Grew (*Musæum Regalis Societatis*, 1681, 25) catalogued a reputed pair of such horns in the collection of the Royal Society, but thought it probable that they had belonged to a small deer.

This puzzle may perhaps be explained by the experience of

American naturalists, who are well acquainted with similar growths in the cottontails inhabiting the dry regions of the west. Thompson Seton (i., 672, and fig. 181) has figured the head of a prairie hare carrying a pair of horns each about 3 in. long, and distinctly resembling those of a roebuck. But there may have been something wrong about this particular specimen, of which he remarks that it was in a sealed glass case, so that a close examination was impossible. The growths appeared to be of real horn, and had no resemblance to those which he had hitherto seen on "Rabbits" (*i.e.* hares).

In any case, the existence of horned hares is now proved to admit of a reasonable explanation, and it is possible that the phenomenon may in Europe also be restricted to the drier parts remote from the British Islands. The description of the American "horns" by Nelson (*North Amer. Fauna*, No. 29, 1909, 24) may be copied in its entirety :—"A more curious but less serious disease is most common among cottontails west of the Mississippi River. This is the growth of long, conical, horn-like excrescences on the skin, usually on the head, which appear to have a close similarity to warts and not to affect the general health of the victim. These excrescences vary in number from one to half a dozen and are an inch or two in length. They stand out at right angles from the skin, and look like little horns. Sometimes they grow symmetrically on the top and sides of the head, giving the animal a remarkable appearance."

The **chase** of hares has occupied the attention of mankind from the remotest period of which there exists any record, and the ancient Egyptians and Assyrians have left drawings of it on their monuments (see Wilkinson, *Manners and Customs of the Ancient Egyptians*, ed. Birch, 1878, ii., 78-92; Layard, *Nineveh and its Remains*, 1849, ii., 430); the former kept hares in special preserves.

A hound resembling a modern greyhound appears in the Egyptian sculptures, but there is nothing to show exactly how it was used. It is, however, remarkable that hunting with dogs is nowhere mentioned in the Bible, and the word "greyhound," which appears in the authorised version of the Book of Proverbs (xxx., 31) should probably be rendered "horse," *i.e.* "war-horse," as is suggested in a marginal reading of the Revised Version.

Hare-hunting was mentioned by Homer (? 850 B.C.), both in the *Iliad* and the *Odyssey;* and it is also referred to in "The Shield of Hercules" (line 302), a poem ascribed, but with doubtful propriety, to Hesiod (? 700 B.C.; see ed. Paley, 1883). It was a favourite amusement of Xenophon, who (in a treatise mentioned on p. 235) described it as already a well-organised sport of long standing, although, as might have been expected, not so advanced as under modern methods, since Xenophon seems to have had very little idea of giving the quarry "fair play."

Another Greek writer of repute, Arrian, who was born about the close of the first century of the Christian era, was probably the first to describe true coursing in a work also named *Cynegeticus.* Of this a most valuable critique and translation into English, entitled *Arrian on Coursing*, was published anonymously in 1831 for Bohn's library; but in the unsigned article on "Coursing" in the 11th ed. *Encyc. Brit.*, 1910, vii., 321, its author is stated to have been the Rev. W. Dansey.

Amongst the most interesting parts of Arrian's work is his account of his favourite greyhound "Hormé," whose manners and habits appear to have differed in no important detail from those of modern dogs.

According to Arrian the Gauls of his day were very keen coursers, and their hounds formed a definite breed already well known as the "canis gallicus."

As a matter of fact, these early greyhounds were not always used according to modern notions of legitimate sport, but were often combined with the slower hounds that hunted by scent, as is well shown in two plates[1] opposite pp. 182 and 196, in Baillie-Grohman's 1909 edition of *The Master of Game.* It was, therefore, not until our ancestors began to separate the usage of hounds which worked only by sight from those employing scent, and to restrict the former to the pursuit of a definite quarry, that a state of things approaching modern conditions came in view.

In other respects very little real difference is perceptible

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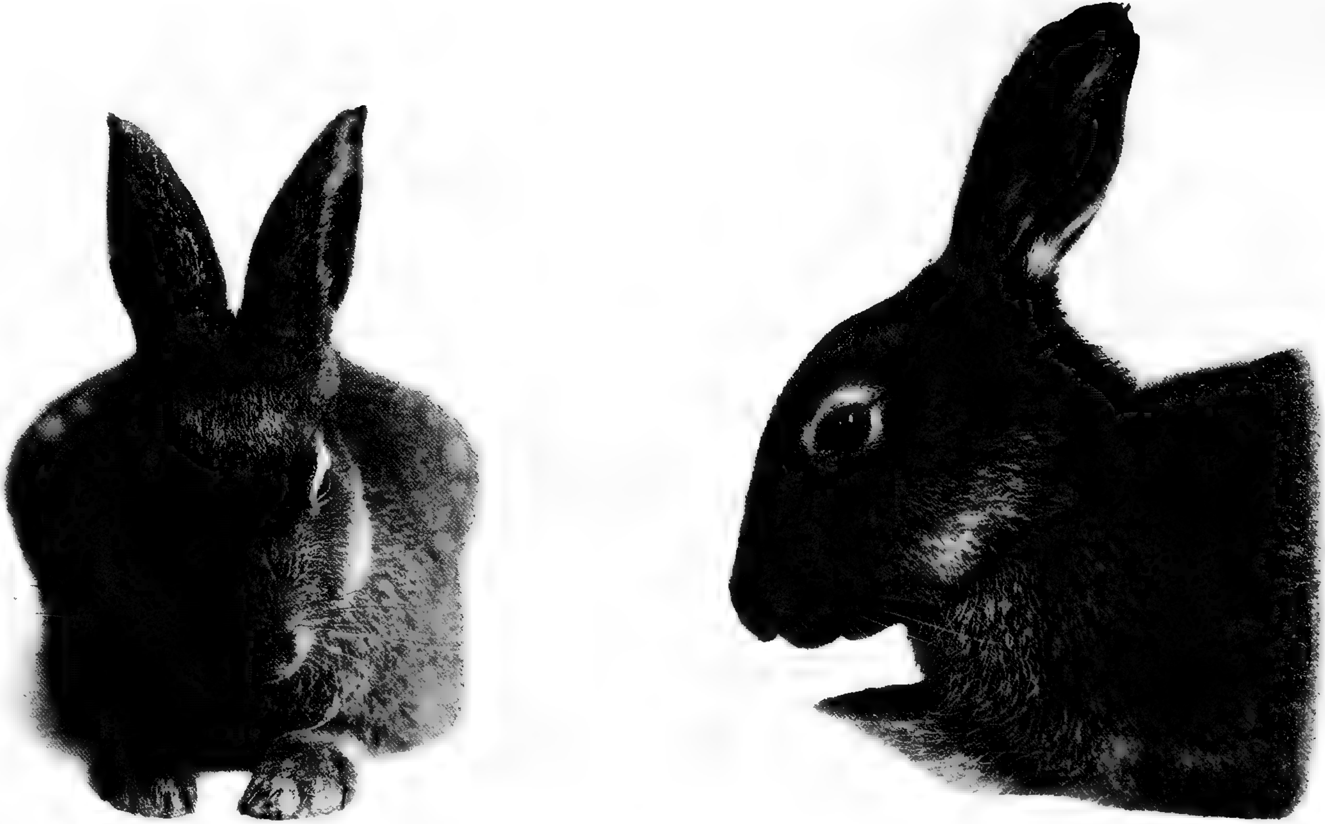
[1] These, with others of great interest published in the same work, are reproduced from a French MS. of Gaston de Foix's *Livre de Chasse*, no satisfactory English illustrations of the period being available.

PLATE XVIII.



HEAD OF IRISH HARE (*Lepus hibernicus*), Male.

between the methods of modern and ancient coursing. In both periods the votaries were of two classes; those who wished to fill their pot, and those who wished to test their hounds. The latter have always shown the true spirit of sport, and the words of Arrian (*op. cit.*, 108-109)—"For coursers, such at least as are true sportsmen, do not take their dogs out for the sake of catching a hare, but for the contest and sport of coursing, and are glad if the hare meet with an escape"—could not be improved upon in our own time. Thus the spirit of the modern courser breathed in Arrian, whose ideas are shown to have advanced in no small degree as compared with those of his predecessor and acknowledged master, Xenophon.

In point of time others preceded Arrian, since several of the great writers of classical Rome described or mentioned the sport. It was, for instance, casually touched upon by the poets Virgil, 70-19 B.C. (*Georgics*,[1] i., 307), Horace, 65-8 B.C. (*Epod.*, 2, 35), and Ovid, 43 B.C.—A.D. 17; the latter's descriptions (*Metamorphoses*, i., 533, and vii., 780) of a single-handed course being the first found in the literature of classical Rome. Martial crowned the hare chief of all quadrupeds in the line—*inter quadrupedes mattea*[2] *prima lepus* (*Epigrammatica*, xiii., 92), and Julius Pollux (*Onomasticon*), Oppian (*Cynegetica*), and Nemesian (*Cynegeticon*) each wrote special treatises on its capture. The later Romans held it in great estimation, hunted it with a special breed of hounds, and confined it, with other animals, in special enclosures. Thus Varro (*De Re Rustica*, bk. iii., chap. xii.) states that Pompeius formed a park ("septum") in France (Gallia Transalpina), containing the compass of four thousand paces, wherein he preserved, not only hares, but also dormice and bees; and the "leporarium" therein was so constructed as to be impenetrable to cats, badgers, wolves, and eagles.

The honour surrounding hares, has, however, been very unequally distributed, and there have been nations and sects, such as the followers of Zoroaster, as well as the Mohammedans, Copts, and Jews, to which their flesh was, or is, entirely forbidden.

[1] "Tum gruibus pedicas et retia ponere cervis,
Auritosque sequi lepores."

[2] In some versions *gloria*.

The reason for this prohibition amongst the ancient Hebrews, as laid down in Leviticus xi. 6—"And the hare, because he cheweth the cud but divideth not the hoof, he is unclean to you"—was certainly not founded on fact. Hares have, however, a curious habit, as pointed out by Drane (*op. cit.*, 106), of grinding their incisor teeth when sitting in their forms, as well as of passing their food twice through their body, which may have led to the belief that they chew the cud. The habit of grinding the teeth is mentioned also by Woodruffe-Peacocke (*op. cit. supra*, 10), who finds that it is used by British Brown Hares as a means of passing along an alarm.

In Britain, as known to Julius Cæsar (*De Bello Gallico*, v., 12), hares, although plentiful, were accounted unclean beasts and unfit for food, a prejudice still in force in the Isle of Man, where, according to Kermode (*Zoologist*, 1893, 63), "the natives would not think of eating a hare."

The animal plays, however, an honourable, though mythical part, in some legends; for Queen Boadicea is said to have released one from her cloak at the conclusion of her famous oration, and the story goes that by its fortunate course her soldiers were inspired to victory. (Xiphilinus's *Epitome of Dion Cassius's Historia Romana*, bk. lxii.)

The history of early British sport is very meagre, but in later times there were tabulated in Wales elaborate rules governing the chase; and these may be found amongst the laws of Howel the Good (see *The Ancient Laws of Cambria*, 1823, bk. i., 367), who is said to have reigned as paramount King of Wales from A.D. 940 to 948. In those days the pursuits of the hare, fox, and roebuck were accounted the "three clamorous hunts." Hare's flesh was also reckoned next after that of the stag in the list of the "best flesh of the chase" (*op. cit.*, 368), and before that of the wild boar and bear; but, strange to say, the skin or fur is not included in the interesting list of values found in the same work (bk. iii., 232).

Under the Anglo-Norman kings the British Hare was highly esteemed by sportsmen, and it is often alluded to in literature of the period. It appears to have given the name to a special breed of fast hounds or *leporarii* in 1184 (*Stubb's Select Charters*, 1895, 157), and a royal pack of harriers is mentioned in 1485 ("Wanderer," *Field*, 30th March 1912, 652).

In Twici's *Art of Hunting*, written about 1327, the animal heads the lists of hunted beasts, and the reason given is "Because she is the most marvellous beast which is on this earth. It carries grease,[1] and it croteys,[2] and gnaws, and these (things) no beast in this earth, does except it. And at one time it is male and at another time it is female." The last reason is imaginary, and the earlier ones are based on the technicalities of the chase; but the quotation well illustrates the high regard in which the animal was held.

In the most famous hunting book of England, that of Edward, second Duke of York, who was the Master of Game to King Henry IV., A.D. 1406 to 1413 (see Baillie-Grohman's eds. of 1904 and 1909), itself largely a translation from the even more famous French of Gaston de Foix (*Livre de Chasse*, A.D. 1387), the hare again heads the list of "beasts of venery and chace," coming even before the stag. Any modern sportsman might envy the Master of Game's knowledge of its habits, and his opinion of it is given as follows (ed. 1909, 14):[3]—"The hare is a good little beast, and much good sport and liking is (*sic*) the hunting of her, more than that of any other beast that any man knoweth, if he were not so little."

In the *Boke of St Albans* (1486) the hare retains a high, or even a higher position, for we read that "That beest Kyng shall be calde of all venery. . . . He is the mervellest beest that is in any londe."

By most subsequent writers, such as Shakespeare,[4] coursing, although laxly prosecuted, is taken as a matter of course, and the description of a hunted hare in *Venus and Adonis* is probably the finest in the language. But it is a remarkable thing that in France, the apparent land of the birth of coursing, that branch of hare-hunting declined so much that an English translator of Du Fouilloux's French treatise *La Venerie*, from which in 1575 or thereabouts he compiled *The Noble Arte of Venerie*, on account of the absence of any description of it in the French work, was compelled to introduce an original chapter on the subject.

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[1] A technical term used amongst sportsmen for the fat of some animals of the chase, see below, p. 254.

[2] "Croteys" were droppings, see below, p. 254. Apparently the hare was the only beast combining grease and croteys; all others with grease had fiants (Dryden's *Twici*, 1908, 38).

[3] Note the hare is here called "he" and "she" indiscriminately, in accordance with the strange belief of the time regarding its sex, see above, pp. 239-240.

[4] "If I fly, Marcius, halloo me like a hare."—*Coriolanus*, I, 8.

"Say thou wilt course; they greyhounds are as swift
As breathèd stags, ay fleeter than the roe."
—*Taming of the Shrew*, Introduction, sc. 2.

Coursing, as we understand it now, dates from the time of Queen Elizabeth (Blaine, *Encyc. Rural Sports*, 1875, 562 and 584), in whose reign the first set of English rules for determining a course were drawn up by Thomas, Duke of Norfolk. No open trials were heard of, however, until half a century later in the time of Charles I., and the oldest regular coursing club, that of Swaffham, Norfolk, dates only from 1766 ("Coursing," *Encyc. Brit.*, 11th ed., unsigned).

Hares were formerly taken with hawks, but this sport, like **hawking** generally, is now, for practical purposes extinct in England. It is practised, however, and is very popular in several parts of the world, especially amongst some of the wilder Asiatic tribes; and it must have appealed strongly to the Greeks of classical times, for the capture of a hare by a large bird of prey was considered worthy of description by Homer (*Iliad*, xxii., 391), by the poet Æschylus in his tragedy *The Agamemnon*, and by Aristotle (ed. Thompson, 191, ix., 32, 619^a, 36, etc.), the latter of whom refers to a particular raptorial bird as the "hare-killer" (*op. cit.*, ix., 32, 618^b, 30).

According to Poland, there has not been in recent years much traffic in British **hare skins**; but in old days the reverse must have been the case, since Fleming[1] states that as many as thirty thousand—of course not all Brown Hares—have been sold in Dumfries market in February.

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[1] See also Robert Service, *Scott. Nat.*, July 1891, 97-102.

GROUP EULAGOS.

British Hares fall into two groups, distinct in origin, structure, and habits.

The first, for which Gray's name *Eulagos* (1867) seems to be available, includes *L. mediterraneus*, *L. europæus*, *L. granatensis*, with their allies, and probably a number of Old-World hares other than the varying hares as differentiated below. In *Eulagos* the head is smaller, the eyes less prominent, the ears and tail longer, and the limbs, especially the fore, shorter. The pelage is coarse, not woolly, without marked juvenal or post-juvenal changes, the whiskers are long and coarse, the upper side of the tail is black, and there is a conspicuous autumnal moult. There are only six mammæ.

In the **skull**, as exemplified by *L. europæus*, the brain-case is narrower and deeper than in *L. timidus*, the frontal region is not concave, and the superciliary processes are but little raised above the level of the skull, so that the profile of the cranium is fully arched. The nasals are large, their greatest length, as a rule, considerably exceeding that of the median frontal suture. The anterior portion of each zygoma is relatively shallower, the distance from the anterior termination of the groove on the outer surface to the front edge of the arch being greater than the least depth.

In the **teeth** the upper incisors are broader, more curved, and their roots do not extend beyond the premaxillo-maxillary sutures. The posterior upper premolars are short, their height measured from crown to extreme upper point of root-capsule within the orbit being less than the alveolar length of the tooth-row, instead of being greater, as in the varying hares of the group *Lepus*.

The **mandible** is characterised by its relatively low dimension of height, a consequence of the shorter molar crowns, by the slightly broader incisors, and by the ventrally broad symphysial region, which has its inner margin sharp, instead of rounded, as in the varying hares.

The differences between the skulls and teeth of *europæus* and *timidus* are discussed by Hinton (*Sci. Proc. Roy. Dublin*

Soc., xii. (N.S.), No. 23, September 1909, 225, etc.), who gives numerous references to the literature, including the work of Nathusius, Forsyth Major, Winge, Lönnberg, Lyon, and Nelson.

In *L. europæus* the scapula is proportionately narrower than in the varying hares.

This group, which in Britain is represented by *L. europæus*, is only a comparatively recent immigrant into Western Europe, where it has superseded the members of the true *Lepus* group. The broader and shorter incisors and less deeply-rooted upper cheek-teeth suggest that its members are naturally graziers on soft grassy herbage rather than on the stronger stalks of herbaceous plants, bushes, or the bark of trees. The longer ears, extremely long whiskers, more highly developed olfactory region, and less prominent eyes, are probably indicative of a more nocturnal habit. The fur is that of a recent immigrant from less rigorous regions than those at present occupied by the true hares, and the lesser number of mammæ point to smaller, although, perhaps, more frequent litters of young.

No doubt further subdivision will be required when the members of the group *Eulagos* are better understood. The main convenience to systematists of the present arrangement is that it defines the group of true *Lepus*, under which is given a fuller discussion of the distinctions.

THE COMMON OR BROWN HARE.

LEPUS EUROPÆUS, Pallas.
LEPUS EUROPÆUS OCCIDENTALIS, de Winton.

1666. LEPUS, *a Hare*, Christopher Merrett, *Pinax*, 168.

1693. LEPUS, Λαγὼς Græcis, The Hare, John Ray, *Synopsis Methodica Animalium Quadrupedum*, etc., 204.

1756. LE LIÈVRE, L. J. M. Daubenton in E. L. le Clerc, Comte de Buffon's *Histoire Naturelle*, vi, 264-299; described from Burgundy, France.

1777. LEPUS TIMIDUS (species, *nec* Linnæus), J. C. R. Erxleben, *Systema Regni Animalis*, 325 (part); Berkenhout; Turton; Bingley; Fleming; Jenyns; Bell (ed. i.); MacGillivray; Fatio.

1778. LEPUS EUROPÆUS (species), P. S. Pallas, *Novæ Species Quadrupedum Glirium Ordine*, 2, 30 (part); naming Daubenton's "Le lièvre" = *L. europæus europæus* (Pallas); Lydekker; Thomas, *Zoologist*, 1898, 101; Johnston; Millais; Winge; Hinton, *Sci. Proc. Roy. Dublin Soc.*, xii. (N.S.), No. 23, September 1909, 226; Trouessart (1910).

1857. LEPUS TIMIDUS, b. mitteleuropäische form, J. H. Blasius, *Säugethiere Deutschlands*, 417 (part).

1898. LEPUS EUROPÆUS OCCIDENTALIS (sub-species), W. E. de Winton, *Ann. and Mag. Nat. Hist.*, February, 152; described from Herefordshire, England (type No. 98.2.17.1 of British Museum Collection); Hilzheimer, *Zool. Anzeiger*, xxx., 512, 14th August 1906; Trouessart (1910).

Le Lièvre of the French; *der Hase* of the Germans.

The **synonymy** and **history** given here is mainly that of the British Brown Hare, *L. europæus occidentalis*, a recognisable sub-species first differentiated by de Winton in 1898. That of the species as a whole and of the other sub-species will be found in works on European mammals, and is in all cases quite simple, since, under the rules of priority, there can be no doubt about the correct names for the Brown and Blue Hares. Yet there has been much confusion in the past, owing to causes similar to those surrounding the synonymy of the bats and shrews. The Hare to which Linnæus applied the name *timidus* is not the common hare of Europe; but this fact was not at first understood, so that this name was widely applied to the present as being much the better known species. After the discovery of the identity of the true *timidus*, some naturalists retained that name for the Brown, and adopted Pallas's name *variabilis* for the Blue Hare. This course is still followed by a few zoologists, especially biologists and those working on extinct forms; but the majority of authoritative systematic writers have now, although not without protest, agreed to adopt the next available name, viz., Pallas's *europæus*, for the Brown Hare, leaving the Blue Hare to be *Lepus timidus*, as originally intended by Linnæus. The names of other sub-species will be found under *Geographical variation.*

Sex names:—Jack, or buck; jill (and gill), or doe.

Terminology:[1]—The word *hare* appears in Middle English, as in Chaucer. The Anglo-Saxon form is *hara*, the Swedish and Danish *hare*, and the Icelandic *heri* (for an original *here*). But in the Dutch, Middle Dutch, and Old High German forms, the original "s" is retained in place of the "r," from a Teutonic stem, *hason*. On the other hand, the Welsh *ceinach* = "a hare," is believed to be certainly connected with *sasnis* = "a hare"—one of the very few words of Old Prussian (Slavonic dialect) which have been preserved. This appears in Sanskrit as *çaça* (for an original *çasa*), a word which was assimilated by popular etymology in Sanskrit with *çaç*, to jump; but the real meaning of the original Sanskrit form was certainly "grey." The original signification of *hare* is thus shown to be the "grey animal"; with which compare *grey*, a name of the Badger. Thus the Anglo-Saxon words *hasu* = "grey-brown," and *hara* = "a hare," are directly connected.

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[1] Without reference to species.

Hare is also used both as a surname and in place-names (*e.g.*, Harewood, Yorkshire), and appears in many compounds and names of flowers, as hare-lipped, hare's-ear, hare's-foot, hare's-tail, harebell, and others. To "make a hare of a man" is a well-known Irish expression signifying to rout him completely, especially in argument, as in a well-known popular song—"Father O'Flynn would make hares of them all."

By sportsmen "hare" is often used in the feminine gender.

The sex-names "jack" and "jill," or "gill," are survivals of familiar but somewhat depreciative Middle English terms for "boy" and "girl"; compare the old nursery rhyme beginning "Jack and Jill went up the hill." "Jill" or "gill" is from Middle English "jille," "gille," "jylle," or "gylle," abbreviated from "Gillian" = "Julian," from "Juliana," from Latin "Julia," feminine of "Julius"; compare "gillet" or "jillet" = a giddy young woman, a jilt (*Dial. Dict.*).

"Leveret," the common word for a young hare, comes, as shown below, from the French.

Local names[1] (non-Celtic):—*Bandy*, from the curvature of the hind legs, of East Anglia, including Norfolk; *baud* or *bawd*, a shortened form of *bawdrons* = "a cat," of Scotland, Derby, and Nottingham—see also under Wild Cat,—explains an otherwise pointless passage in *Romeo and Juliet*, II., iv.—

"*Mercutio.* A bawd, a bawd, a bawd, so ho!
Romeo. What hast thou found?
Mercutio. No hare, sir;"

as well as the following from *Poems in Buchan Dialect* (1783, 23), quoted by Jamieson—

"I saw (and shame it was to see)
You rin awa' like bawds";

bautie, *bawtie*, *bawty*, of Scotland and Cumberland, is also applied to dogs; *bettie*, of Kirkcudbright (Service, *Zoologist*, 1878, 427); *bun*, see Rabbit; *cuttie* = "short"-tailed, of Scotland, a name usually applied to the wren; *donie* = "the little dun-coloured" animal, given by Jamieson as of the Angus dialect, but not known to Wright's correspondents (*Dial. Dict.*); *fennel*, a female hare when giving suck; *fuddie*, of Banff and Aberdeen, from *fud*, the tail of a hare or rabbit, as in Burns's *Tam Samson's Elegy*, 1787, vii.—

"Ye maukins, cock your fud fu' braw,
Withouten dread,
Your mortal fae is now awa'";

great hare, a three-year-old; *jack-rabbit*, see Rabbit; *katie*, of Scotland, Cumberland, and Shropshire; *laverock* or *lavrock*, of Northumberland and the North of Ireland, evidently a mistake for *leveret*, a young hare, as explained below; *malkin*, of Scotland and North Yorkshire, from *maldkin* or *maudkin*="little Maud," a familiar cat-name transferred to the hare (cf. *grimalkin*, a cat="grey malkin," of some parts of Scotland, and of Northumberland and Cumberland), appears also as *maukin* or *mawkin; mally*, of Durham; *mapsie*, a pet or young hare (*Dial. Dict.*), see Rabbit; *old aunt*, of Norfolk, as in Emerson's *Birds, Beasts, and Fishes of the Norfolk Broadland*, 1895, 325; *old Sarah*, of Suffolk (compare *Sarah* of Yorkshire); *puss*, a quite general term, as in Cowper's well-known poem; *scut*, see Rabbit; *wat* or *watty*, corrupted from *Walt*=*Walter*, an old familiar name, still in use locally, and of some antiquity, compare Shakespeare's

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[1] Without reference to species.

> "And when thou hast on foot the purblind hare,
> Mark the poor wretch . . . . .
> By this, poor Wat, far off upon a hill
> Stands on his hinder legs with listening ear"
> (*Venus and Adonis*);

whiddie and *whiddy*, of Aberdeen, Banff, Orkney, and Shetland, the sense of which is "nimble," as in Taylor's *Poems*, 1787, 91—

> "Rob then to her did hunt his dogs . . .
> But Whiddie wi' her cockit lugs,
> Said, 'Kiss your luckie.'"

In old sporting books "the Hare is a *Leveret* in the first year, a *Hare* in the second, and *a great Hare* (*cf.* "great cony," above, p. 189) in the third" (Daniel, *Rural Sports*, 1801, i., 260); of these terms, *leveret* is from Old French *levret*, diminutive of Old French *levre*, modern French *lièvre*—from Latin *lepus*, genitive *leporis*="a hare."

Besides those mentioned above, a surprising number of fanciful names were bestowed on the animal by Anglo-Norman sportsmen, amongst whom there must almost have been a cult or worship of it; see above, p. 246, etc., under genus *Lepus;* many of these may be found in Wright and Halliwell's *Reliquiæ Antiquæ*, and I have reprinted them (*Zoologist*, 1911, 25-26). Westropp informs me that a somewhat similar set of fanciful appellations existed in the Irish language, and they may possibly have been derived from the Normans also.

Amongst the old sporting terms, "meuse," "muse," or "smeuse" is still retained in many districts to indicate the openings or passages by which a hare is accustomed to pass through a hedge, and is also used sometimes to signify her "form." It is from the Old French *musse*="a little hole" or "corner to hide things in," from *musser*=to hide, and was also applied in connection with other animals, such as the wild boar. The word "muset" was used in the same sense by Shakespeare in *Venus and Adonis*, in connection with a hunted hare—

> "The many musits through the which he goes
> Are like a labyrinth to amaze his foes."

Another old term, the "relief" of a hare, from the French *relever*= to arise, hence=her arising to go to her pasture, and in later usage= her feeding, seems to have fallen into disuse.

A hunter was said to "quest" or "seek" for a hare. This, in the time of Twici, huntsman to King Edward II., he did with a "limer" or "lymer," that is a scenting hound led in a "liam" or leash, which practice, however, seems to have died out subsequently, since it is not advocated as a part of hare hunting by *The Master of Game.* When found in its form, the animal was "moved" or "started." When caught it was "stripped" or "eased" of its "skin, and its fat was usually known as "grease," as by Twici and the Master of Game, but in *The Boke of St Albans* it is called "tallow."

The old MSS. contain many other sportsmen's terms. The droppings were known as "crotels," "croties," or "crotishings." We read of "A huske of hares, a don of hares"; again, "A hare ys formed schulderyng or lenyng . . . a cony sytteth" (MS. Digby, 196, 160-161; 15th century MS. in Bodleian Library, Oxford).

Of the numerous epithets applied to hares, the most famous is "mad," which is confined to the expression "mad as a March hare" (*cf.* however, "hare-brained"). This idea has been immortalised anew by "Lewis Carroll" in *Alice in Wonderland*, but is of old standing, since it is mentioned in an early 15th-century (about 1420) translation of Palladius on *Husbondrie* (Early Eng. Text Soc.), 62, lines 36-38—

"Yit in this moone is for to sowe tares
And not in March, lest they ennoie thi beestes,
Thi oxen might be woode thereof as hares."

The two next most common epithets are "timid" or "timorous," and "melancholy." The latter has been variously, but never yet satisfactorily explained; it occurs in Shakespeare, as in *Henry IV.*, i., 2—"What sayst thou to a hare, or the melancholy of Moorditch?" According to the author of *The Noble Arte of Venerie* (1575, 160), the hare "is one of the moste melancholike beastes that is"; and this supposed quality is discussed in Baillie-Grohman's editions of *The Master of Game.* The beast figures also as the "merry brown hare," as in Charles Kingsley; "purblind" in *Venus and Adonis* (see above, p. 253); and "intelligent," the latter quality, as well as that of timidity, being shared with the stag in Aristotle's *Historia Animalium* (ed. Thompson, i., 1, 488^b 15), and being therefore of very ancient origin.

(Celtic):—Old Irish—*cermna* (Cormac) is glossed as meaning "brown hound in the brake"; the same explanation is given of the modern Irish *fiadmuin*, *fiamuin*; *gearr-fhiadh* (pronounced *gearree*), literally="small deer"; *miol mhaighe*="beast of the field" or "plain"; *pata*, *patan*, with diminutives *paiteog*, *patachan*, *pheatán*, the latter in Wilde, *Proc. Roy. Irish Acad.*, vii., 1862, 188.

Scottish Gaelic—*gearr* = "a hare," *gearrag* = "a young hare or leveret," and *maigheach* = "the 'field' animal," from *magh* = a "field" or "plain," are general terms, to which (*fide* C. H. Alston) *bhàn* is added for *L. timidus* in winter, and *ruadh* ("red") for *L. europæus.*

Manx—*mwaagh* (= Scottish *maigheach*).

Welsh—*cath eithin*, lit. = "cat of the furze"—compare the old English name "furze-cat" applied to the hare in *Reliquiæ Antiquæ*, I., 133; *ceinach*, a hare (already mentioned); *ysgyfarnog*, lit. = "the eared animal," from *ysgyfar* = "an ear," and *ysgyfarn* = "the ear of a beast."

Cornish—*scovarnek*, *scovarnog.*

Distribution:—The Common Hare is found naturally in several sub-specific forms from Great Britain to the Ural mountains; and from Scotland, Denmark, the shores of the Baltic, and the White Sea districts of North Russia (Blasius), southwards to the river Ebro in Spain (Cabrera, *in lit.*), Italy, the Balkan Peninsula to the Peloponnese, the northern shores of the Black Sea to the western shores of the Caspian, the districts south of the Urals, and south at least to Trebizond.

It is quite a recent immigrant or introduction in Scandinavia and Finland, where, as in Arctic Europe generally, in Ireland, and in the higher portions of the Alps, members of the group of varying hares are alone indigenous; in Sweden, it now ranges north of 56° N. lat. (Lönnberg), and in Finland is spreading northwards.

It meets in Spain a very distinct hare, *L. granatensis* of Rosenhauer (1856) = *L. meridionalis* of Graells (1897) = *L. lilfordi* of de Winton (1898), which is found in the Balearics, and Iberian Peninsula south of the Ebro, but in the north-west ranges up to the Pyrenees and just into France. This is a small species, with hind feet measuring (including the claws) 115 to 125 mm., characteristic skull, the outer surfaces of the thighs bright ochraceous, and the feet marked with white; it has three sub-species.

L. europæus does not occur in Sardinia, where is found *L. mediterraneus* of Wagner, a distinct small hare of dull coloration, with long ears, and the hind feet (including the claws) measuring 95 to 108 mm.; and it is not indigenous either to Corsica or Sicily, its presence in both those islands being due to introduction. Thus Polybius (*History*, § 12) stated that in his time (B.C. 204) it was unknown in Corsica, and, as regards Sicily, Julius Pollux (*Onomasticon*, v., § 12) quotes Aristotle as stating (in a lost work) that the tyrant Anaxilas of Rhegium introduced hares into that island, thus explaining their presence on the coinage of Sicily and Rhegium (see Hill, *Coins of Ancient Sicily*, 1903, 47). The same authority gives details of the introduction of hares in Karpathos, to the detriment of the crops. *L. europæus* appears to be absent also from the Parnassus mountains of Greece, whence Miller has recently described *L. parnassius*, which resembles *L. creticus*, but is larger, has longer ears, and distinct skull and teeth. The representatives in Crete and

Cephalonia, and in Cyprus are two closely allied hares, *L. creticus* of Barrett-Hamilton and *L. cyprius* of Barrett-Hamilton. The former is a comparatively small hare (hind feet, 120 to 135 mm.), with relatively long ears; the latter is similar, but has the cheeks and ears suffused with buff.

The eastern boundaries of the range of *L. europæus* are still very imperfectly known, and from the Talysh and Mugan steppes Satunin has described *L. cyrensis*, a form of doubtful affinity, while in the East, in parts of Asia Minor, Egypt, and North Africa, occur a number of species, the relationships of which still require elucidation.

Amongst the countries where *L. europæus* has been introduced are La Plata (Thomas, *Ann. and Mag. Nat. Hist.*, March 1910, 246), New Zealand (Macpherson, *The Hare*, 7), Barbadoes (Wallace, *Encyc. Brit.*, 11th ed., art. "Acclimatisation"), and Jersey, where, however, it may have been previously indigenous (Bunting).

[*L. europæus* is said to have died out in Switzerland and to have been reintroduced; some specimens of the new stock in the collections of the British Museum of Natural History are of the sub-species *occidentalis*.]

In the **British Islands** *L. europæus occidentalis* is not indigenous to Ireland, but, where not persecuted, is abundant throughout **England**, **Wales**, and **Scotland**, except on the higher parts of the mountains. It does not object to the vicinity of towns and villages, and Boyd Watt has seen one inside Queen's Park, Glasgow. It was plentiful in some of the London parks until some time in the nineteenth century, there being records of the capture of one in Hyde Park in 1809, and of coursing matches held in Regent's Park between 1824 and 1828 (Harting, *Essays on Sport and Nat. Hist.*, 1883, 234-235). One was killed at Hammersmith in 1892 (Cornish, *Shooting*, 1903, ii., 161), and another in fields surrounded by houses between Walm-lane and Brondesbury Station (Bulleid, *Field*, 24th June 1899, 907). There is, however, almost unanimous testimony amongst local naturalists that its numbers, although now, perhaps, again on the upgrade, have been much reduced since the passing of the Ground Game Act of 1880. Before that date its abundance in some districts was quite extraordinary, and the damage done to farmers must have been very great. To give a Scottish instance, it was stated that in Kincardineshire (Robertson's *Agricult. Surv. Kincardineshire*, 1807, quoted by Sim), hares "are incredibly numerous, abounding in many parts in dozens in every field. I am fully persuaded that there are many more Hares than Sheep in this country, only they have changed places. The great body of Sheep are sent to pick up a scanty subsistence on the barren hills; but the Hares, left to the freedom of their own will, prefer to live at their ease in the low and rich parts of the country. Without having seen it, one could hardly conceive the quantity of turnips that they destroy." In Suffolk, at Sir Thomas Gooch's in 1806, there were killed no less than 6000 (Blaine, *Encyc. of Rural Sports*, 1875, 508; *Shooting*, cit. supra, 17). In much later years 823 have been shot on one short December day in 1869, and 1217 during three consecutive days of November 1878, in different localities. Of late years, however, the species has run considerable risk of extermination where it has not the sanctuary of a big preserve; in many localities it has disappeared or is becoming yearly scarcer, and in most it is described as decreasing. Still, big bags continue to be obtained by sportsmen in favoured localities, and in 1902, in Cambridgeshire, 1100 were shot in a single day (Cornish, *op. cit.*, 154-155). Many coursing clubs also flourish all over the country, and in 1911 there were 132 packs of harriers, of which 40 were Irish (*Field*, 14th October 1911, Suppl., xvii.-xviii.).

This hare has a predilection for situations in which its favourite food-plants are plentiful, and on such ground it is most numerous, as well as heavier and more healthy. Millais mentions as favoured resorts the fens of Lincoln, the wild, open, sandy districts of Norfolk, Suffolk, and Cambridge, the lowlands of Essex, and the great fields of Shropshire; and in Scotland, the border counties, the Earn and Tay valleys, Donibristle in Fife, and the neighbourhood of Elgin and Forres. Cornish (*op. cit.*) thought that, considered as hare preserves, probably there is in the south nothing quite like the marshes of Southminster, Essex; Cliffe, Kent; and Sudbourne, between Aldborough and Hollesley, Suffolk; but in such localities floods are sometimes very destructive, as when the phenomenal high tide of 1898 drowned many hares at Orford.

On the whole, this hare is to be found in artificial rather than in natural country, in cultivated fields rather than on moors, in plains rather than on mountains. But it is not absolutely restricted to these more pleasant haunts. In North Wales, according to Forrest, it likes high ground to over 2000 feet; and in Scotland generally is found up to about that limit. In the Moray area it follows cultivation far up the glens (Harvie-Brown and Buckley). In the Edinburgh district, although most numerous in the plains, it occurs in all the hill-valleys, and in summer even encroaches on the ground occupied by the Blue Hare on the hill-slopes (W. Evans). Millais has seen one shot at 2500 feet during a White Hare drive in Scotland, and has frequently killed them on the hills above Pitlochry, Perthshire, at about 1500 feet.

In the highlands and north of Scotland the range of the Brown Hare has always been more restricted, owing to the comparative scarcity of suitable ground; but it is, or was locally common in many districts to the extreme north of Sutherland and Caithness.

It is hard to give a list of **islands** to which this hare is indigenous, as it is so often introduced. It is present in Wight

(Bury, More), Anglesey, and Man; but in the latter introduction may be suspected, although no records of it exist. It is not found in Lundy. Alston states that it does not appear to be indigenous in any of the Scottish islands, but it has been very generally introduced, as in Bute, Great Cumbrae, Arran, Islay (previous to 1816), Jura (Millais), Mull, Calve (Millais), Tiree, Coll (about 1787), Skye (Millais), and probably many others (Alston, Boyd Watt, Harvie-Brown and Buckley, Millais). To Mull it was introduced in 1814 or 1815 (Alston); but in 1895 MacLaine of Lochbuie wrote (*Ann. Scott. Nat. Hist.*, 1895, 250), that, although it was at one time plentiful, and throve well until a few years previously, it had then completely disappeared, in spite of the fact that fresh blood was imported on several occasions. That writer was at a loss to account for its total disappearance, and suggested that the want of cropping had had much to do with it. One, supposed to be the last of its race, shot in Mull on 13th December 1882, weighed 12 lbs., a weight which does not suggest deterioration.

In the Outer Hebrides the Brown Hare has been introduced on many occasions, as, for instance, in Lewis, Harris, and Barray, and its numbers have fluctuated from time to time, apparently in accordance with the amount of protection accorded to it by game preservers (see Harvie-Brown and Buckley). In the Orkneys it is now common (Harvie-Brown and Buckley), and has been introduced on Mainland (Pomona), as well as in Hoy, Eday, Rousay, Shapinshay, and South Ronaldshay (Millais). It is believed to have died out on Papa Westray (Harvie-Brown and Buckley).

In the Shetlands it was introduced early in the last century, and occurs on Mainland from Dunrossness to Mossbank (Millais).

It has been introduced into many parts of **Ireland**, and in 1898 it was possible to give details (*Irish Naturalist*, 1898, 69-76) of twelve such introductions. The imported animals succeeded in establishing themselves wherever they were given a fair chance. One of the most conspicuous instances was that of Strabane, where in 1876 65 hares are said to have been brought over from Norfolk. They throve very well, and in 1893 there was "a splendid stock of hares" (Herdman, *Land and Water*, 4th March 1893), the descendants of which still remain in numbers about Strabane, and are even said to be the only kind of hares found in that neighbourhood (D. Ker, *in lit.*, 16th December 1910).

Distribution in time:—Bones of hares have been described from numerous cave-deposits extending back to the pleistocene age. These have been variously identified with *L. europæus*, or, as from a Somerset cave, by Sanford (*Quart. Journ. Geol. Soc.*, London, xxvi., 1870, 126, pl. viii., f. 5; and *Proc. Somerset. Nat. Hist. Soc.*, xv., 1870, 53, pl. 5), with H. von Meyer's *L. diluvianus* (*Palæologica*, 1832, 61).

But the latter species, although doubtfully distinct from *L. timidus* (Woldrich, *Sitzungsb. d. K. Akad. d. Wissensch.*, Vienna, lxxxii., 1880, ii.), and placed in the synonymy of that species by E. T. Newton (*Quart. Journ. Geol. Soc.*, lv., 421, August 1899), was described from continental Europe, and is therefore not of direct interest to British naturalists.

Forsyth Major has, however, shown (*Geol. Mag.*, dec. v., vol. i., 1904, 143) that all the British pleistocene remains of hares determinable with certainty are referable to allies of *L. timidus.* Hinton has come to a similar conclusion as the result of his studies of the late pleistocene fossil hare of Ightham, Kent (*Sci. Proc. Roy. Dublin Soc.*, xii., N.S., No. 23, pl. xv., Sept. 1909, 225-265). He further informs me that he cannot recall a single instance of any undoubted remains of *L. europæus* of even prehistoric age in Britain; even a single right tibia from the Roman camp at Corstopitum, near Corbridge-on-Tyne, Northumberland (see Meek and Gray, *Arch. Aeliana,* 3rd ser., vii., 125, 1911), is referable to true *Lepus.* Winge, however, finds *Eulagos* in neolithic deposits in Denmark, but considers it very rare. The species must certainly be regarded as a comparatively recent post-pleistocene immigrant, and its presence points either to a very late land-connection with the Continent, or to introduction in early historical times. For the latter hypothesis no confirmatory evidence can be adduced. But it is not improbable, and has parallels in the frequent practice of introducing hares throughout the known historical period. This conclusion is consistent with the absence of Brown Hares from Ireland, where, however, as shown above, they thrive well when introduced, and with their recent extension of range (though assisted by man) in Scotland, Scandinavia, and Finland (see under *Distribution*).

Origin:—It seems almost certain that *L. europæus* invaded western Europe from eastern Europe or Asia, as its status in the Mediterranean region indicates that it could not have come from north-western Africa; it must, therefore, have entered both Spain and Italy from the north in recent geological times. This irruption can hardly have been connected with amelioration of climate, since the animal is very hardy; but, as it appears to have everywhere superseded the members of the *L. timidus* group where meeting them, the matter is discussed more conveniently under heading of the latter species.

Description:—In general form and appearance this animal embodies the typical characters of a hare. Amongst European species it is distinguishable by its large size, long ears[1] much exceeding the head in length, distinct dorsal colour pattern, lack of noticeable contrast between the colour of the sides of the body and of the outer surface of the thighs, and by the absence of white markings on the feet.

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[1] As in the case of rabbits (see above, p. 194), specimens with deformed ears are sometimes seen, and one such from Bottisham Hall, Cambridge, in which, apparently by congenital defect, all sign of external ear, or even of opening, was lacking, was described by Jenyns (*Observations on Nat. Hist.*, 1846, 77). Other instances have from time to time been recorded, amongst others by Wise, *Field,* 15th Sept. 1888, 413; Clayton, *Journ. cit.*, 3rd Jan., 1891, 10; "R. L.," *Journ. cit.*, 8th May 1909, 801.

The **fur** contains the three typical components (see above, p. 162). The middle hairs are more prominent than in the Rabbit, hence the pelage is not so soft as in that animal. The whiskers and superciliary tufts are much thicker and longer than in the varying hares, and the fur on the soles coarser and harder to the touch.

The **colour** of the underfur is on the back whitish, with conspicuous dusky tips, becoming unicoloured "buff" or "ochraceous buff" on the flanks, and on the belly unicoloured white.

In the hairs, the usual order of the rings from the tip downwards is, as in the wild Rabbit, black, "ochraceous buff," black, and at the base some lighter shade; the dark tip may, however, be absent, so that the upper side of the animal, including the top of the head, is, for the most part grizzled ochraceous buff, with a not very considerable mixture of dusky where the underfur or the black hair-tips show. The shoulders, flanks, neck, nape, throat, and a band across the inguinal region are ruddier, without black, and may in richly-coloured individuals almost reach a ruddy "ochraceous brown." The flanks are sprinkled with long whitish or buff hairs having dusky bases. The sides of the face are yellower or lighter than the upper side, and these, with two more or less clearly defined bands passing from nose to ear, and including the eye, may be grey or nearly white, especially in winter. The outer surfaces of the limbs are lighter and yellower than the back, there being no black-tipped hairs. The under side is white, with the exception of the pectoral and inguinal bands already mentioned, and the inner surfaces of the limbs whitish. The tail is more or less black above; beneath white, the white overlapping and showing on the margins of the upper side. The thickly furred soles are a dirty yellowish white shade. There are numerous black or white whiskers, of which the white are the longer, and may reach a length of 90 mm. The eyelashes and a tuft of strong hairs above each eye (length 71 mm.) are black. The ears are thickly covered on the outer surfaces with short hairs, which are usually black with ochraceous tips; the inner surfaces are sparsely clothed with tawny hairs, and the bases and anterior surfaces resemble the back in colour, but are lighter. Each ear has a more or less conspicuous black apical tip, which shows only as a thick rim on the internal surface, but on the external extends downwards for a distance of about 30 mm.; beneath each black tip an indefinite band of grey spreads on to the external margin as a distinct rim.

In the hind **feet** (see Plate XX.) the two longer central and the two shorter outer digits form subequal pairs; the second is slightly longer than the fifth, and the third than the fourth; the hallux is absent.

Of the five toes on the fore feet the central is the longest, the thumb shortest and very small, but carrying a strong nail. The second, fourth, and fifth are intermediate in size in the order named. All digits carry strong claws. With the exception of insignificant tracts (figured by Boas, *Zool. Anzeiger*, xxxv., 15th February 1910, 442-443), the palmar and plantar surfaces are completely, and, according to the season, more or less heavily clothed with fur, which conceals the terminal pads of the digits and three rudimentary pads lying at their bases.

Newly born **leverets** have very short ears and a less furry tail than adults, which they soon grow to resemble, but are less thickly furred on the under side, and lack the ruddy tints of the chest and back, as well as the extra long hairs. There does not seem to be any conspicuous juvenal or post-juvenal coat.

According to the older sporting books, bucks appear to be smaller in the body than does, shorter in the head, whiter on the rump, redder on the shoulders, and greyer on the ears. The first, second, and fourth items are certainly correct; the others require further investigation.

The principal **moult** is effected in the late summer or early autumn, between July and early October (latest examined, 5th October). The fur of the back may come off altogether. The new hairs are then seen short and black without whitish bases or ochraceous tips, so as to be very conspicuous. The ochraceous tips appear as the hairs grow; later the whitish base. There seems to be a gradual change of coat in late winter or spring; Cocks (*in lit.*) has examined specimens in which the hairs were loose and the coat of the upper side not yet renewed on 11th February, and again in the last weeks of May and August; and Drane finds the fur of tame individuals in a continuous state of change throughout the year.

White facial marks are by some considered an indication of age, appearing in captive individuals at about the sixth year (Drane, MS., per Proger); together with a grey rump and whiter tail and ears, they are sometimes found in summer specimens which have not moulted properly. But they are really characteristic of the **winter coat**, which is whiter, but in a variable degree, than that of summer, so that no doubt many of the pied or grey varieties noticed below under individual variation are instances of incipient winter whitening. In such cases the ochraceous bands of the hairs disappear and the black bands are reduced in breadth. Two specimens which seemed to have undergone extensive whitening were reported from Dumfriesshire by Gladstone (*Ann. Scott. Nat. Hist.*, 1911, 113), on 20th December 1903, and 27th December 1910. In one the legs were brown; the other was "completely white, with only a suspicion of a brown hair here and there." It is probable that individuals in more or less completely white winter dress are obtained annually, especially in Scotland, and Masefield writes me of some instances which occurred near Leek, North Staffordshire; but the majority escape recognition, being mistaken for Mountain Hares.

The skull and **teeth** are typical of the group *Eulagos*, as described above on p. 249.

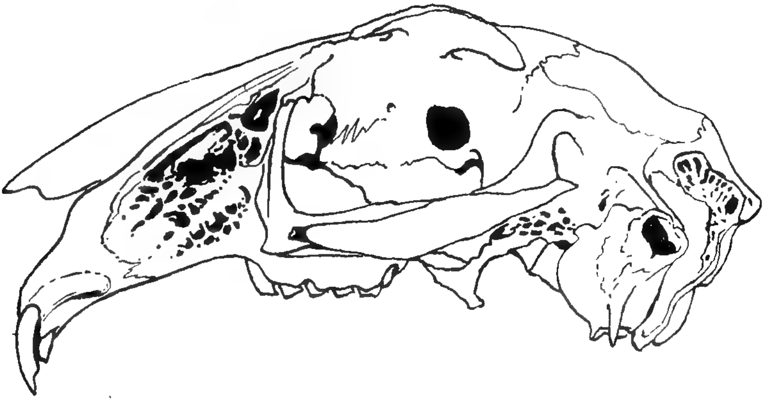


FIG. 47.—SIDE VIEW OF SKULL OF *Lepus europæus* (life size).

Individual variation of colour is frequent, or rather it is frequently reported, as the animal is so much under the public view that practically every conspicuous variety is noticed by sportsmen or keepers.

Black varieties (which, like black rabbits, seem to lack the white underside, see p. 198), are rare, but at least fifteen instances have been recorded, including two leverets. Some of them may have been individuals undergoing autumnal moult, as described above

Two rich ochraceous specimens, both quite immature, in the Tomes collection at the British Museum of Natural History, are labelled "Weston Sands." To this class probably belong two tawny Scottish females in the Perth Museum, for a note of which I am indebted to Rodger.

Cream-coloured and white specimens, with the eyes pink or brown, are more numerous than the black, and are occasionally found as leverets; but records of white or whitish varieties need careful verification, as they may have reference to the regular grey variety described below, to specimens undergoing winter whitening, or to introduced Blue Hares. Sometimes varieties of the above type are recorded to have occurred more than once, or periodically, in the same district; and two, a male and female, were shot on the same day near Perth, and are now in the museum of that town (Rodger, M.S.). White or pied specimens with blue eyes have been three times reported (Nicholls, *Field*, 21st April 1888, 547; Whitaker, *Zoologist*, 1889, 143; Hunt, *Field*, 5th October 1895, 590), and "white hares" are said to have been occasionally shot at Cubberley near Cheltenham (Witchell and

Strugnell). A "blue grey" leveret recorded by Warde Fowler (*Field*, 3rd February 1906, 182) was first seen in August.

When the face is spotted with white, there may be in extreme cases a white forehead (Gunn, *Zoologist*, 1866, 385); "face pure white" (Bury, *Zoologist*, 1844, 789); or the head, ears, and part of the neck white or grey (Clark-Kennedy, *Zoologist*, 1869, 1558). A breed of white-faced hares was reported from Lincolnshire (Rudkin, *Field*, 12th February 1910, 290). In a specimen sent to the British Museum of Natural History by Heatley Noble, from Carradale, Argyll, on 15th January 1907, the white spots, often found in other specimens at the bases of the ears, meet at the nape, and the stripes from nose to ear are white, as they are also ordinarily in some Continental sub-species (see R. L., *Field*, 2nd February 1907, 183). So many individuals possess a white spot on the forehead that a belief has arisen that this indicates a buck, or one of a litter of four (see Cornish, *Field*, 14th May 1892, 704); as stated above, Drane considers white spots on the face a mark of age.

Pied, skewbald, or mottled specimens occasionally occur, the legs, feet, back, or sides being affected (see Clark-Kennedy, *Zoologist*, 1869, 1558; Whitaker, *Zoologist*, 1887, 233; Nicholls, *Field*, 12th April 1888, 547; Hunt, *Field*, 5th October 1895, 590; Tegetmeier, *Field*, 14th October 1899, 640).

There is a remarkable **grey variety** of both sexes, which has often attracted attention, and which appears, at least in all thoroughly authenticated instances, to have been observed only in autumn and winter (specimens examined were killed between 6th September and 22nd January). In this the normally ochraceous annulations of the hairs are white, and throughout the body white replaces brown or rufous of any shade wherever these occur in typical examples, and, in extreme cases, there is lightening or reduction of the black portions of the coat. This form has been recorded from, amongst other counties, Ross-shire, Ayrshire, Oxford, Bedford, Berkshire, Suffolk, Dorset, Norfolk, and in some districts would appear to be well known. Thus one or two are said to occur nearly every season in Norfolk (Gunn, *Zoologist*, 1866, 385; see also *Encyc. of Sport*, 1897).

This grey variety is strongly reminiscent and suggestive of winter whitening, a process which occurs regularly in some of the Continental sub-species of *L. europæus*. This fact, together with its prevalence in those parts of England which are coldest in winter, and its restriction to that season, suggest that it may be interpreted as a sporadic assumption of a white winter coat.

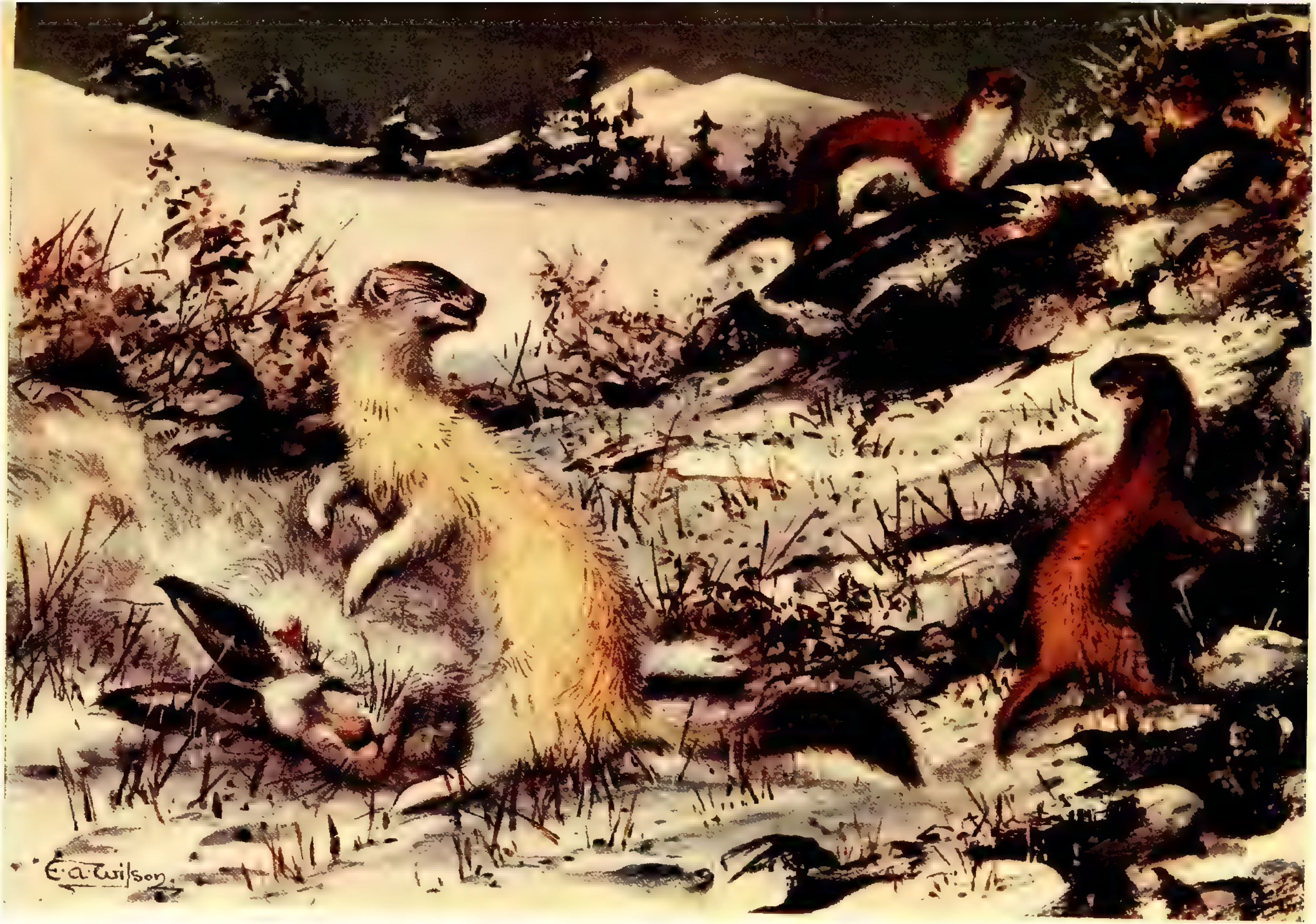
Local variation:—Hares vary in weight in different counties. Thus Cocks finds that on the Berkshire downs they are heavier than in Buckingham; in Orkney they are, according to Millais, darker and heavier than either in Scotland or England; amongst Scottish specimens those from the Earn and Tay valleys attain great weights.

Woodruffe-Peacocke (*op. cit.*) believes that British Brown Hares can be divided into two intergrading sub-species; those of Scotland having a heavier, greyer coat in winter than those of the south of England.

Geographical variation:—*L. europæus* is a plastic hare, of which several sub-species have been recognised. In the typical form, which ranges from the Atlantic, except Britain, to Germany, and from Denmark to central France, the hind feet (including claws) run to about 150 mm., the colour is light and yellowish, and a pale winter coat is frequently assumed (= Nilsson's *Lepus medius*, 1820). The British form (*L. e. occidentalis*) is, on the average, not so heavy; its coloration is richer and darker, and it more rarely assumes a pale winter coat; both the above have whitish bases to the underfur. *L. e. pyrenaicus* of Hilzheimer, of the Pyrenees and south-eastern France, resembles the typical form, but is smaller, having hind feet measuring up to 135 mm. *L. e. corsicanus* of de Winton is about the same size as the last, but is yellower and has conspicuously buff bases to the underfur; it is found in Italy (Rome), whence it was introduced in classical times to Corsica and Sicily. *L. e. hybridus* of Desmarest (=*L. aquilonius* of Blasius = (?) *L. caspicus* of Ehrenberg), of eastern Germany to Russia and eastwards to Astrakhan, is a large light hare; the hind feet measure at least 165 mm., the cheeks are whitish, the rump buffy grey, and a grey winter pelage is habitually assumed. *L. e. transsylvanicus* of Matschie (=*L. e. transsylvaticus* of Hilzheimer), of inexactly known distribution from Roumania south through the Balkan peninsula to the Peloponnese, has the hind feet reaching 154 mm., and a bluish-grey rump strongly in contrast with the back; this form has been introduced into Denmark. *L. e. meridei* (Hilzheimer), a doubtfully distinct form found from south central and south-eastern France to northern Italy and in Corfu, is very like *L. e. europæus*, but its coloration includes more brown and less buff; it has a bluish-grey rump, not, however, contrasted with the back, as in *transsylvanicus*. Hilzheimer's *carpathorum* of the Carpathians is probably also distinct. Other sub-species may occur in Asia Minor, but they have not yet been studied. *L. europæus* certainly occurs at Trebizond.

Dimensions in millimetres:—

Skull (range of two males Nos. 95·1·19·1 and 98·2·11·1 in the British Museum of Natural History):—Occipito-nasal length, 94·2 and 97·4; condylo-basal length, 82·8 and 85·4; zygomatic breadth, 44·6 (both); breadth at inter-orbital constriction, 20·4 and 22; breadth at post-orbital constriction, 13·4 and 11·2; breadth of brain-case, 31·4 and 30·8; nasals (diagonal), 41 and 42·2; greatest breadth of both nasals



MOUNTAIN HARE, STOAT, AND WEASEL IN WINTER PELAGE.

together, 21·2 and 22·4; length of diastema, 27·2 and 27·8; length of mandible, 69·8 and 73·2; length of maxillary tooth-row, 18·2 and 17·8; length of mandibular tooth-row, 19·4 and 18·8 (continued on p. 268).

EXTERNAL CHARACTERS:—

	Head and body.	Tail.		Hind foot.		Ear.		Weight.	
		With terminal hairs.	To end of vertebræ.	With claws.	Without claws.	To notch.	To nape.	Lbs.	Oz.
MALES FROM NORFOLK:—*									
1.	595	89	..	151	..	101	128	8	8
2.	538	112	..	148	..	100	132	7	0
3.	535	96	..	152	..	100	132	7	8
4.	539	121	..	149	..	100	132	7	8
5.	535	85	..	147	..	102	129	7	4
6.	532	111	..	152	..	102	130	7	8
7.	540	120	..	149	..	102	132	7	10
8.	532	118	..	150	..	104	132	7	4
9.	542	110	..	151	..	100	130	7	0
Average of 9 Norfolk males . . .	543	107	..	150	..	101	131	7	7
FEMALES FROM NORFOLK:—*									
1.	577	111	..	149	..	97	128	7	10
2.	590	112	..	147		95	120	7	12
3.	535	115	..	152		97	128	8	8
4.	520	90	..	152		97	128	7	8
5.	531	109	..	151	..	105	132	7	12
6.	520	94	..	148	..	95	115	8	4
7.	535	100	..	148	..	98	132	8	0
8.	534	111	..	150	..	100	128	7	6
9.	540	100	..	151	..	102	132	8	2
10.	538	110	..	150	..	97	125	7	10
Average of 10 Norfolk females .	547	105	..	149	..	98	126	7	13
Average of both sexes from Norfolk .	545	106	..	149	..	99	128	7	10
MALES FROM SCOTLAND:—†									
1. Strathora, near Perth, 29th Sept. 1911 . . .	520	..	95	146	..	90	117	7	14
2. Do. do. . .	527	..	98	147	..	92	120	6	10
3. Do. do. . .	514	..	89	147	..	92	120	6	10
4. Do. do. . .	549	..	98	159	..	95	127	7	9
5. Do. do. . .	530	..	95	140	..	92	124	6	11
6. Bridge of Earn, Perth, 6th Oct. 1911 . . .	538	..	98	146	..	92	124	7	10
7. Perth, 12th Feb. 1912 . . .	514	..	76	143	..	99	124	6	4
8. Do., 21st Feb. 1912	539	..	95	140	..	90	112	7	..
9. Do. do. . .	552	..	101	140	..	90	108	6	4
10. Do. do. . .	571	..	95	140	..	90	114	8	..
Average of 10 males from Scotland .	535	..	94	144	..	92	119	7	2

* The Norfolk specimens were specially selected as fully adult, and measured by T. V. Sherrin, 10th February 1911, by kind permission of Messrs Kerry Brothers, Smithfield Market, London.

† The Scottish specimens were measured by A. M. Rodger.

EXTERNAL CHARACTERS (*continued*):—

	Head and body.	Tail.		Hind foot.		Ear.		Weight.	
		With terminal hairs.	To end of vertebræ.	With claws.	Without claws.	To notch.	To nape.	Lbs.	Oz.
FEMALES FROM SCOTLAND :—†									
1. Strathora, near Perth, 29th Sept. 1911 . . .	539	..	101	152	..	90	114	8	10
2. Do. do. .	546	..	98	143	..	92	120	7	12
3. Do. do. . .	520	..	92	149	..	95	124	7	1
4. Do. do. . .	552	..	98	147	..	95	124	9	5
5. Do. do. . .	527	..	92	140	..	99	127	7	3
6. Bridge of Earn, Perth, 6th Oct. 1911 . . .	539	..	101	147	..	95	127	7	8
7. Do. do. . .	542	..	95	143	..	95	120	8	..
8. Do. do. . .	514	..	92	152	..	95	127	7	12
9. Do. do. . .	514	..	88	147	..	90	114	7	10
10 Perth, 12th Feb. 1912 . . .	589		95	140	..	92	127	7	..
11. Do. do. . .	583		76	149	..	92	127	7	6
12. Do. do. . .	589		101	152	..	99	130	6	..
13. Do. do. . .	552	..	83	140	..	90	114	8	..
14. Do. do. .	574	..	98	152	..	102	130	9	..
15. Do., 21st Feb. 1912	546	..	89	146	..	95	120	7	12
Average of 15 females from Scotland .	538	..	93	146	..	94	123	7	11
Average of both sexes from Scotland .	537	..	93	145	..	93	121	7	7
MALES FROM VARIOUS LOCALITIES :—									
1. Just adult, Merton Hall, Norfolk, 28th January 1898 (Lord Walsingham, No. 98.2.11.1 of British Museum collection) . .	545	..	86	..	138	101	143	7	7
2. Norfolk, 15th Oct. 1911 (L.E. Adams)	570	..	..	150	..	..	..	7	15
3. Moorhampton, Hereford, 20th Nov. 1897 (W. E. de Winton, No. 3.1.26.1 of British Museum collection) . . .	556	..	87	..	135	98	121	..	..
4. Hambleden, Bucks, 3rd June 1911 (A. H. Cocks)	533	136	79	139	..	82	130	..	..
5. Do., 11th June 1911 (A. H. Cocks)	482	120	70	..	113	85	120	..	..
6. Do., 22nd June 1911 (A. H. Cocks)	494	120	74	129	..	85	115	5	8
7. Ditto, juv., 26th Aug. 1911 (A. H. Cocks) . . .	515	113	81	133	..	84	122	..	..
8. Surrey, 16th Oct. 1911 (L.E. Adams)	560	..	..	140	..	98	180	6	8
9. Grey variety, Tulloch Castle, Dingwall, Ross, and Cromarty, 29th Sept. 1903 (S. Dennis, No. 3.11.14.1 of British Museum collection) . .	540	..	72	..	136	99	..	..	..
10. Isle of Man, 17th Jan. 1895 (P. M. C. Kermode, No. 95 10.19 1 of British Museum collection) . .	530	..	76	..	132	102	..	..	..
11. Very young, 3rd Sept. 1906 (No. 6.9.18.1 of British Museum collection) . . .	149	..	26	..	34	27	..	..	3¼

EXTERNAL CHARACTERS (*continued*) :—

	Head and body.	Tail.		Hind foot.		Ear.		Weight.	
		With terminal hairs.	To end of vertebræ.	With claws.	Without claws.	To notch.	To nape.	Lbs.	Oz.
FEMALES FROM VARIOUS LOCALITIES:—									
1. Adult, Merton Hall, Norfolk, 8th Jan. 1898 (Lord Walsingham, No. 98.2.11.3 of British Museum collection) . . .	588	..	80	151	..	103		8	13
2. Barely adult, Merton Hall, Norfolk, 8th January 1898 (Lord Walsingham, No. 98.2.11.2 of British Museum collection) . .	575	..	90	..	141	98	..	7	13
3. Moorhampton, Hereford, 7th Jan. 1898 (W. E. de Winton, No. 98.2.17.1 of British Museum collection). Type of subspecies, *L. europæus occidentalis* of de Winton .	570	..	86	..	135	99	131	..	..
4. Hambleden, Bucks, 21st May '11 (A. H. Cocks, contained 2 embryos)	532	95	70	138	..	66	120	6	14
5. Do., 27th Sept. '11	535	113	74	132	..	91	130	6	7½
6. Surrey, 16th Oct. 1911 (L. E. Adams)	580	..	..	145	..	95	126	6	1
7. Berkshire, 18th Oct. 1911 (L. E. Adams) .	573	125	..	145	..	105	130		..
8. Do. do. . .	580	130	..	154	..	100	140	..	..
9. Adult, Pangbourne, Berks, 14th Oct. '10 (Capt. Sawbridge, No. 0.11.16.1 of British Museum collection) . .	..	..	75	..	139	99	..	..	..
10. Immature, grey variety, Southleigh, Oxon., 6th Sept. 1893 (A. J. Butler, No. 93.9.7.1 of British Museum collection) . .	515	..	93	..	123	..	..	..	..
11. Isle of Man :— One (? sex), 18th Dec. 1900 (*coll.* C. H. B. Grant, No. 18) . . .	543	..	89	..	134	110	..	..	..
12. One, do. (No. 31) .	538	..	67	..	131	105	..	..	..
Approximate proportionate lengths, calculated from the averages of the Norfolk and Scottish specimens, head and body being reduced to 100 and all other dimensions proportionally. *N.B.*—The results for both sexes and localities are so close that it has not been considered necessary to separate them.	100	..	17·5	27/27·5	..	17·2/18·5	22·2/24	..	..

Skull (*continued*):—3 females, Nos. 98.2.11.2, 98.2.11.3, and 98.2.17.1, of the British Museum, the last being the type of de Winton's subspecies *occidentalis*:—Occipito-nasal length, 96·6, 98·2, 98·8; condylo-basal length, 86·6, 86·4, 87·4; zygomatic breadth, 45·4, 47·4, 45·2; breadth at inter-orbital constriction, 22·2, 20·4, 23·2; breadth at post-orbital constriction, 13·4, 14·4, 15; breadth of brain-case, 31·6, 31·4, 32·4; nasals (diagonal), 44·4, 42·4, 45; greatest breadth of both nasals together, 22·4, 21·2, 21·8; length of diastema, 28, 27·4, 26·2; length of mandible, 74, 75, 73; length of maxillary tooth-row, 18·8, 19, 19·2; length of mandibular tooth-row, 18·8, 20, 19·8.

The largest skull (sex unknown) in the British Museum (No. 97.3.8.1, from Vaynol Park, Bangor, North Wales) exceeds the above dimensions, so that they cannot be regarded as representing the maximum; the corresponding measurements are:—100·4—88·8—48·2—22—13·6—34·8—44·2—21—30—77·6—18·4—19·2.

Weight, in pounds and ounces:—This varies with the locality and sex, females being usually heavier than males, but the average for animals of both sexes in good condition is generally taken as 7 to 8 lbs., with a good number reaching 9, very few 10, and, rarely, higher weights. According to Millais, those from Scotland scale highest, especially from the Orkney Islands and the valleys of the Earn and Tay; but Harting finds Lincolnshire specimens unusually heavy. Exceptional individuals may sometimes be accounted for by introductions of continental races, or by their having been accidentally emasculated. A few individuals weighing over 13 lbs. have undoubtedly been killed, but some of the records mentioned below may not be reliable; all are, however, if correct, exceptional and noteworthy:—

Female, 10 lbs. 8 oz. (Laver); one, 10 lbs. 10 oz. (Monro, *Field*, 5th December 1874, 594); one, 10 lbs. 12 oz. (Chamberlin, *Field*, 14th February 1891, 215); one, 11 lbs. (Patterson, *Nature in Eastern Norfolk*, 318); two,[1] 11 lbs. 3 oz., on two occasions (*Field* editorial, 24th December 1887, 962); one, 11 lbs. 8 oz., near Doncaster (Nevile, *Field*, 23rd August 1873, 223); two, 11 lbs. 12 oz. (Mason, Lincoln, and Frost, Suffolk, *Field*, 10th November 1877, 545); three, 11 lbs., 11 lbs. 12 oz., 12 lbs., Murthly, Perth (Millais); one, 12 lbs., Mull, introduced (MacLaine of Lochbuie, *Ann. Scott. Nat. Hist.*, 1895, 250); one, 13 lbs. (Craven, *Field*, 1st January 1887, 14); one, 13 lbs. 1½ oz. (Jenyns, evidently from "A. B.," *Loudon's Mag. Nat. Hist.*, v., 1832, 276, a female sent to Leadbeater from Norfolk); one, 13 lbs. 4 oz., shot, October 1876, by Robert Henderson on the Longwitton Estate, near Morpeth, Northumberland (Hoskins, *Field*, 28th October 1876, 499); one of the same weight, mentioned in the *Field* of 24th December 1887, 962, was the same individual which is also noticed by the editor, *Field*, 1891, 215, and probably elsewhere; one, 13 lbs. 8 oz. (Kennedy, *Field*, 28th January 1888, 107); one, 13 lbs. 14 oz., killed by a keeper on the estate of the Misses Farringtons, Worden (J. T. H., *Field*, 14th December, 1878, 752, from the *Preston Guardian* of 11th December 1878).

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[1] It was probably one of these specimens to which Harting (*Encyc. of Sport*, 1897, i., 503) alludes as having been killed on the farm of Mr Tupholme, at Eastville, near Boston.

Distinguishing characters:—The pale, dusky-tipped hairs of the underfur form probably the most diagnostic character at all ages as between the Brown Hare and the other three British species of *Leporidæ*. Amongst adults, the long ears, reaching well beyond the nose, are unmistakable.

The skull-characters are given very fully on page 249.

The "timorous flying Hare"[1] has almost come to be regarded as the embodiment of speed and timidity.[2] Its prominent eyes and elongated, mobile ears are excellent organs for the discovery of danger, while the long, slender hind limbs are admirably adapted for the most rapid flight. And yet it is remarkable that hares should be so timid. They are at worst creatures of immense muscular power; armed with sharp claws and teeth, they possess considerable facilities of defence, as any one may learn who attempts to hold one. Had they the necessary confidence they would be no mean adversaries for the smaller carnivores, and, when tamed, they easily hold their own against the household cats and dogs.

Although in many respects resembling rabbits, there are as many differences in the habits of the two animals as in their structure. Whilst rabbits excavate burrows, whither if alarmed they instantly betake themselves, hares make only superficial depressions, called "forms."[3] These they use only as resting-places, trusting to remaining motionless[1] for safety, and, when discovered, to speed and endurance.

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[1] Shakespeare, *Venus and Adonis;* compare also such phrases as "More a coward than a hare" (Shakespeare, *Twelfth Night*, iii., 4); "Poor is the triumph o'er the timid hare"; and "The fearful hare," of Izaak Walton's *Venator;* and, for other instances, see above, p. 254.

[2] In this article use has been made of E. Adrian Woodruffe-Peacock's lecture, "The Cultivation of the Common Hare," being No. 7 of his *Rural Studies Series;* also of the "Fur and Feather" Series—*The Hare;* and the "Badminton Library"—*Shooting, Field and Covert; Hunting; Coursing and Falconry.*

[3] Hence the printer's word, "forme."

A hare is at ordinary times a solitary animal, spending the day quiescent[2] in its "form," which it leaves in the evening to seek its food. Exceptionally, as when tempted by the rich repasts offered at harvest time, or during the sexual season, it becomes apparently gregarious; but the gregariousness is only superficial, and the members of the temporary party, if disturbed, disperse each on its own resources. Although as a rule restricting its excursions to a not very extensive area, there are times when a hare may travel long distances, one having been tracked for thirty miles in a night.[3]

Its tastes and appetite are capricious, and its wanderings lead it to some luscious field of clover, to the parsley of a kitchen-garden, to lie out on a salt marsh, or to sea-beaches, where, according to the late C. J. Cornish,[4] the chief attraction is the wild sea-pea.[5] But always it is ready for forays outside the shelter of the home pastures. Wander though it may, however, it is an animal of retentive memory, using the same tracks and sometimes returning to the same form for a long period. Unless very much frightened or otherwise losing its bearings, it restricts itself to a particular district, to which it always strives to return, no matter how sorely pursued. It exhibits a peculiar tendency to running along roads or railways. By means of these it sometimes strays so far as to lose itself, so that it fails to return. Sometimes it is surprised and cut to pieces by a train, and thus acquires a reputation for stupidity; but the very same act if undertaken before a pack of hounds is ascribed to special cunning. It is related that it did not appear in the mountainous districts of Lismore and Appin, Argyllshire, until after the construction of roads had opened up communications with the low country;[1] and it may have been in some such way as this that individuals have found their way into parks and towns, as described above on page 256.

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[1] They are not really inconspicuous to trained eyes, unless, of course, when actually hidden by herbage. There used to be a profession made of hare-finding, see Peter Beckford, *Thoughts upon Hunting*, 121 and 127.

[2] According to Robert Collett the crotties of the Skandinavian Hare are usually dropped, one by one, in the morning after feeding and before lying down in the form; and Robert Drane's tame hares were so quiescent by day as not even to defecate. Drane states that anything extruded by day is passed into the mouth and swallowed (*Trans. Cardiff Nat. Soc.*, xxvii., ii., 1894-1898, 101-109, 1895).

[3] Cuthbert Johnson, *Field*, 21st July 1883, 96.

[4] *Shooting*, 1903, ii., 155-156.

[5] *Lathyrus maritimus.*

The form soon takes on a rough oblong cast or print of the animal's body, with smooth sides and the floor trampled or scratched bare by the feet.[2] The shape is probably preserved by the occupant entering only in one direction, sitting quietly while at home, and, it may be, pulling the grass over it with its teeth. Thus it acquires a homely, warm, dry, and comfortable appearance, surprising when it is remembered that it is merely the space formed by the animal when lying down in a tuft of grass or other vegetation.

Forms, however, vary much in detail,[3] for the animal changes its domicile at intervals, and its movements from one situation to another are usually attributed by writers to a capricious but doubtfully existent love of comfort. Undoubtedly hares are very hardy, and warmly clad with fur, and their wants were thus briefly summarised by a recent writer on sport:[4]—"They like dry ground beneath them, but are very indifferent to shelter; it is a common thing to see a hare squatting on the side of a hill with the wind blowing into her fur. In this respect she is far less luxurious than the fox." The general opinion may be further stated somewhat as follows:—The hare does not like very thick coverts, nor those with a drip. In the summer it selects a shady spot, and in the winter an aspect where it may receive the warmth of the sun's rays. It is usually to be found in covert during rain, and in the open in fine, but not in very bright, weather; there are days when, the season permitting, it must be sought for in turnip fields, in stubbles, or amongst long grass and herbage; there are others when it affects naked fallows and ploughed fields. Sometimes it remains in its form,[1] close crouched until almost trampled on; it then lies wide awake and alert of eye, but with flattened body, fore legs drawn back, hind legs concealed, thighs prominent, and ears lying flat V-like on either side of the neck; at other times, especially when bad weather has made it wakeful, it is off long before a sportsman can approach within gunshot. As the hour of the natural evening emergence approaches it becomes wilder and more easily disturbed. In time of snow it often lies still until completely covered, and will not stir until compelled by hunger;[2] or it may sit at the end of a tunnel in a snow-drift.[3]

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[1] J. A. Harvie-Brown, *Proc. R. Phys. Soc.*, Edinburgh, vi., 167, 1880-81, quoting from *New Statistical Account of Argyleshire*, 233. Thomas Pennant (*Tour in Scotland*, 1772, 102) has a similar note referring to the neighbouring districts of Glencoe, Glen Creran, and Glen Ety.

[2] Well described by Gervase Markham (*Country Contentments*, 4th ed., 1631, i., 34), with reference to its appearance as indicative of use and the probability of a hunt.

[3] Beckford (*op. cit.*, 127) remarks that he had heard of a common practice amongst the shepherds on the Wiltshire downs of constructing artificial forms for hares to sit in; and, when made on the side of a hill, it was possible to see at a distance whether they were occupied or not.

[4] The Earl of Suffolk and Berkshire, *Encyc. of Sport*, vol. i., 1897, 559.

The demeanour of a hare when startled in the open is strikingly different from the low, crouching attitude which it generally adopts when in its form. On hearing an unusual sound, its first impulse is to sit upright with erected ears and reconnoitre; afterwards it may endeavour to conceal itself by squatting close to the ground, by skulking away with depressed ears, or it may at once take flight. As a rule the alarm is only partial, and the hare gallops off, holding itself well in hand, its rump thrown high at each leap by the spare driving power of its long hind legs; its ears are widely open, erect, and pricked forwards; its eyes, which are set so far apart as to see separately, observe only backwards. Should the danger not be considered serious, the animal may again halt, stand up erect on its hind legs, and at intervals continue its progress to the shelter of some covert.

If really frightened, the animal goes away at its best pace, wasting no time in looking about it; but it is only as a last resource, as on the near approach of a brace of hounds, that it closes down its ears along its back—a sign that there is no time to observe aught but the terror to the rear—and prepares to do its utmost to save its life. At such times it is all compactness and entirely lacks the appearance of length which is at other times noticeable. Its habit of running "with its eyes behind it"[1] has been known to result in collision with dogs, men, bicycles, cattle, trees, or a member of its own species,[2] with unexpected and fatal results. So sharp is the creature's hearing that Richard Blome[3] notes that of old when warreners wished to prepare hares for the market they filled their ears with wax; the idea being that when not continually disturbed by noises, the animals are quiescent, and grow sleek and fat.

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[1] There is a vivid description in classical Greek of a hare lying at rest in her form, in Xenophon's *Cynegeticus*, v., 10.

[2] H. E. Forrest notes that in the Bala district of North Wales many hares perished in the severe frost of February 1895 (*Fauna of North Wales*, 57). Sometimes the animals become so encumbered with frozen balls of snow in their hair as to be easily captured.

[3] Richard Kearton, *With Nature and a Camera*, 1898, 176.

The short tail may be carried bent over the back like a rabbit's, or it may be pointed straight backwards; countrymen and keepers profess to distinguish males and females by the attitude of this organ. That it has attracted attention from very early times is shown by a remark of "The Master of Game"[4] that "An hare that crumps her tail upon her rump when she starteth out of her form as a coney (does) it is a token that she is strong and well running."

As part of its ordinary routine the Common Hare never enters a burrow like a rabbit, and trusts entirely to speed to escape from its enemies. But, if hard pressed, it will occasionally seek concealment under ground,[5] and where these animals are preserved in numbers for coursing, it is customary to provide them with artificial escapes, usually entered by drain-pipes, in which they are trained to seek sanctuary.

As stated above (p. 169), a hare's gait is peculiar. Owing to the length of its hind legs the animal is believed to be at its best when going uphill, and is said to be obliged to run diagonally in descending a steep bank to avoid overbalancing itself, and, if such a course can be escaped, rarely to run downhill before hounds.

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[1] The old idea was that foxes hear from above, polecats forwards, hares backwards (*vide* an old writer quoted by W. B. Daniel, *Rural Sports*, 1801, i., 286); *i.e.*, foxes catch their prey by stealth, polecats by pursuit, but hares are always pursued. This is supported by the direction of the bony external openings leading to the internal ears, as pointed out by W. Farrar, *Loudon's Mag. Nat. Hist.*, iv., 1831, 9.

[2] For an account of a collision between two hares, see E. T. Booth, *Field*, 6th October, 1883, 490.

[3] *Gentleman's Recreation*, 1686, pt. ii., 95. As in other nocturnal animals, the whiskers, which are very prominent, probably function as organs of touch, especially by night. Drane observed their use as such in his pets (*op. cit.*, 107). But the ears and external nasal apparatus are always twitching and on the *qui vive*.

[4] Anno 1406-1413, ed. W. A. and F. Baillie-Grohman, 1909, 17-18.

[5] References are hardly necessary for such a well-known fact, which was known as well to "The Master of Game" as to twentieth-century naturalists; see, however, E. W. H. Blagg, also Reginald Graham, both in *Field*, 15th February 1896, 258.

As regards the length of pace, a friend of Mr Forrest's has supplied measurements taken on snow, from hind foot to hind foot varying between about 7 feet 6 inches (90 inches) and 8 feet 9 inches (105 inches). In view of Mr W. D. Dovaston's note of the 15-feet[1] leap of a hare from the hiding-place of her young, taken in conjunction with the observations alluded to below,[2] there can be no doubt that much longer distances are frequently attained.

A good instance of leaping power in another direction was placed on record by Mr Alexander E. Parker,[3] who saw a hare clear a wall seven feet six inches in height.

The animal has the reputation of possessing much cunning and of being the master of many wiles whereby to hoodwink its enemies. Mr Kearton,[4] for instance, describes the deceptive way in which it enters its form,[5] but it is probable that the cleverness has been exaggerated,[6] especially by the older writers misinterpreting exceptional incidents or excited by pure imagination. An animal which, ever since the dawn of literature, has lent itself to pursuit or capture in so many forms, and thus to constant observation by a host of sportsmen—not always a very accurate class—very naturally becomes a centre for legends. Amongst the artifices attributed to it by the old French writer, Jacques du Foilloux,[7] are the recognition of the hunter's horn, on hearing which one is said to have run towards a pool at a considerable distance, plunged in, and swam to some rushes in the middle, where it lay concealed. The thoroughly authenticated manœuvres of a hunted hare include doubling back on its tracks,[1] and then leaping off at right angles to start in another direction; entering an outhouse or other building, or lying down in the herbage or ivy on the top of a wall; and Mr J. S. Gibbons[2] has known one to run along the top of a wall so as to throw hounds off the scent, and also to lie down beside a fresh hare,[3] apparently in the hope of shifting the chase to that animal. But, these incidents apart, the activity of the animal, its marvellous powers of leaping and dodging when under pursuit, the value of its flesh as food, and, lastly, its abundance, form a combination of characters so admirable as to require no exaggerated praise. It is not, indeed, surprising that it is still so honoured by sportsmen that the compassing of its end now attracts more attention, and is accomplished with more ceremonial, probably, than that of any other creature except the fox. Similarly, its welfare and preservation have for centuries engaged the attention of Parliament, the result being a long series of Acts, the last of which has probably not yet seen the light.

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[1] Below, p. 287.

[2] See under Irish Hare.

[3] *Field*, 15th February 1896, 258.

[4] *Op. cit. supra*, 176.

[5] " . . . With step revers'd
She forms the doubling maze ; then ere the morn
Peeps thro' the clouds, leaps to her close recess."
WILLIAM SOMERVILLE (1692-1743), *The Chase*, Bk. ii.

[6] Ernest Thompson Seton rates the hares of Manitoba as stupid animals.

[7] *La Venerie*, 1561.

The pursuit of hares for sport by packs of harriers[4] or a brace of greyhounds is probably as popular in Britain as ever. In the case of harriers, puss, although vastly inferior to her[5] pursuers in powers of endurance, is, under fair conditions, their superior in swiftness. The quarry's chance of saving her life is inversely proportional to the size, and consequently the speed of the hounds used. According to Mr Paget, with smart twenty-inch[6] hounds, having good noses and pace, the odds are as much as five to one against a hare, and if assisted by the huntsman, "a perfect pack of harriers should kill every hare they find."

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[1] Often observed, as by J. O. Paget, *Hunting* (Haddon Hall Library), 1900, 259, but seldom analysed from the point of view of the hare, which may sometimes "run her foil" or "lay her maze" prompted by no more subtle feelings than those of indecision and, perhaps, of confusion.

[2] "Fur and Feather" Series, *The Hare*, 221.

[3] J. C. Walter, *Stray Leaves of Travel*, 1910, 177-178, when hunting with beagles, observed an exhausted hare turn out a fresh one and herself lie down in the form just vacated. Paget (*op. cit.*, 257) believes that hunted hares intentionally squat beside fresh ones, and that commonly. He has known one to run along a road for two miles.

[4] A word apparently connected with the verb "to harry" rather than with "hare."

[5] Hares are usually mentioned in the feminine gender by coursing men (above, p. 252).

[6] *I.e.*, height at shoulder.

But, with beagles not exceeding fourteen inches, the odds are three to one on the hare. There is a tendency to use small foxhounds for hare-hunting, and then the hare is soon outpaced, becomes bewildered and succumbs, whereas if she is not too closely hustled, she has time to exercise her wiles in a legitimate manner.

In coursing, the hare depends for safety on its power of sharply turning; in mere speed alone, unless favoured by slippery ground, as on hillsides or in times of snow, it is always very inferior to fresh greyhounds.[1] These are used in pairs and are released, or "slipped," from a leash so as to race side by side at full speed to their hare, which turns to one side just before the pursuers reach her, and they shoot onwards, so that she gains ground and time. During the "course" puss contrives to save her life for the moment by "turns" right about or "wrenches,"[2] but is ultimately caught unless she has time to reach covert. A single healthy hare will usually by its endurance and doubling tire out a single greyhound, and in natural country has a fair prospect of getting away from a pair of dogs, very rarely from three; but in the bare fields of an enclosed and artificial meeting she has but little chance[3] of eluding two picked modern greyhounds unless artificial "escapes" be provided for her. On the other hand, in the spring and on suitable going, individuals are often encountered which are capable of running dogs to a standstill, especially if well (and artificially) fed after a spell of fine weather. I have seen a "bagged" Irish Hare on strange and perfectly open ground defeat every effort of two good greyhounds to catch her until they were thoroughly exhausted and gave up the chase; and

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[1] The slowest greyhound also can easily overtake a fox.

[2] *I.e.*, changes of direction amounting to a right angle, but not right about like a "turn." The value of points in a course and the method of judging will be found in *The Hare*, cit. supra, 155, etc.

[3] Hence, probably, the (at one time well-known) lines of Somerville's (*op. cit. supra*, Bk. i.):—

" . . . nor the tim'rous hare
O'ermatch'd destroy, but leave that vile offence
To the mean, murd'rous, coursing crew; intent
On blood and spoil."

But in most reputable modern coursing meetings "escapes" are provided, if only for economy of the stock of hares.

Mr Charles Richardson once witnessed, but not on a single day, the running off of twenty-seven courses without a single kill; this was in Durham on a thin covering of snow rendered slippery by an overnight frost turning into a thaw.[1]

As the greyhounds always run at their very best pace, the most remarkable feature of the sport is, apart from the high speed, the quite short time occupied by each course. The mere "run up," *i.e.*, counting from the moment of slipping till the quarry is overtaken, is accomplished with almost lightning-like rapidity. The remainder of the course lasts but little longer. It is said that the three final contests of the famous Waterloo Cup, the blue ribbon of the coursing world, occupied in 1889 no more than forty-nine, twenty-eight, and eighteen seconds respectively.[2] The first may be considered quite long, the latter comparatively short, but courses of both longer and shorter duration occur frequently.[3]

The excitement and uncertainty of coursing has been nowhere more vividly portrayed than in the following sentence from *The Noble Arte of Venerie*:[4]—"It is a gallant sport to see how the Hare will turne and winde to save hyr selfe out of the dogge's mouth. So that sometimes even when you thinke that your Greyhounde doth (as it were) gape to take hyr, she will turne and cast them a good way behind hyr: and so saveth hir self by turnyng, wrenching, and winding, until she reach some covert and so save hyr life."

It is when running before harriers that hares give examples of their powers of endurance in another direction. The "Master of Game" was pretty near the mark, as regards the average endurance of the animal, when he wrote:[5] "A hare shall last well four miles or more or less, if she be an old male hare." But in February 1789, in Essex, one is stated to have covered more than twenty miles in two hours.[6] Another, started on Stoke Down, ran, as "it was supposed, . . . near fifteen miles in three-quarters of an hour."[7] The older records were, no doubt, exaggerated, but there are plenty of modern examples of straight runs exceeding five or six miles, without, so far as could be ascertained, any change of quarry.[1] All these may be regarded as exceptional, and indicating that the hunted animal had "lost" itself. Unless hard pressed it will not leave the district in which it lives and which it therefore knows, but will continue to run in circles, as described above.

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[1] *The Hare*, cit. supra, 124, 128, 130.

[2] "White Flag," *Irish Field*, 20th February 1899.

[3] See under Irish Hare.

[4] Anno 1575, 246.

[5] *Op. cit.*, 15.

[6] Daniel, *op. cit.*, i., 330.

[7] *Ibid.*, loc. cit.

One feature of the hare's character, her obstinacy, is often brought out when efforts are made to drive her past a slipper or in any direction against her will. Timid though she is rightly described, it is yet sometimes impossible to drive an unwilling hare, which will again and again face a line of beaters, or even run through an excited crowd of yelling spectators, in order to break back to the region of safety. The same aspect of her character causes her, as stated above on p. 170, to affect certain beaten paths or "trods," which are often the means of her undoing, since they afford an opportunity for the setting of "snares." These are nooses of thin but strong twisted brass wire, firmly pegged into the ground at one end, and so placed that "puss" runs her head through them before she sees them. Since she never attempts to withdraw, the noose closes on her neck and she is held until suffocated. The trods of a hare are not so straight as those of a rabbit, and she prefers to find a way through or round rather than to jump an obstacle.

Although coursing and hunting still flourish as sports, the kindred sport of hare-shooting is growing less popular with keen sportsmen, and is by many regarded as cruel. The animal offers too big a mark to really afford a severe test of skill, unless at such a distance that she may be killed outright by a shot in the head. At all other ranges the so-called sport is mere butchery, and one who has inadvertently wounded a hare is confronted with a sight so pitiable and distressing as to haunt the memory from the beginning to the end of the day.[2]

Although capable of swimming well and taking to water readily when pursued, it cannot be said that hares living in a dry country habitually bathe for pleasure. But if accustomed to water, as when bred near the banks of a river, they "take to it like otters,"[3] and may cross more or less formidable streams,

[1] G. H. Longman, *The Hare*, cit. supra, 188; J. S. Gibbons, *op. cit.*, 217.

[2] Sir Ralph Payne-Gallwey, Bart., *Shooting*, cit. supra, 10.

[3] Earl of Suffolk and Berkshire, *op. cit.*, i., 560. For description of the swimming in *Leporidæ*, see above, p. 224.

or even lakes, in search of food. A field of carrots has lured numbers over the Trent, where it was about two hundred yards wide,[1] and probably the attractions of a mate may transform any robust male into a Leander. So many instances of apparently spontaneous swimming are on record,[2] that particulars of one or two will be sufficient. William Yarrell found one crossing an arm of the sea about a mile in breadth,[3] and in Scotland H. D. Graham[4] often encountered them on little islets lying a quarter of a mile from the mainland, while the late Rev. John Atkinson stated long ago[5] that on the saltings of Essex[6] the hares lie in their forms until overtaken by the tide. Many similar instances have been placed on record.[7]

A hare is as exclusively a vegetable feeder as any known animal. Its food consists of various kinds of herbage, particularly of the mixture known as "grass"; but its choice is much more restricted than that of the Rabbit, and it is said to select comparatively few plants. According to Mr Woodruffe-Peacock, it much prefers the hard fescue, and, after that, the common meadow and the blue heath grasses. Of clovers its favourite is the true cow-grass or marl clover, and on open arable lands it seeks sow-thistles, dandelions, and chicory. In a garden it will attack, before all other plants, dahlias, pinks, carnations, and nasturtiums, parsley, lettuce, and thyme. It will eat also turnips, cabbage, and carrots. To young plantations or shrubberies it is a very annoying and destructive invader, gnawing off the bark and biting the tender young boughs; it seems to have a particular liking for conifers, but, amongst other trees, rhododendron and alder seem to be proof against it, while laurel is very attractive. The leaves of roses and laburnums were the favourites of Mr Drane's[8] "No One," which had tastes different from those of her successor—and cinders were also eaten. The record by Mr George Mawson,[1] that the stomach of a hare killed in winter contained a number of haws, is probably exceptional, as is a similar one in regard to holly berries.[2] Mr Woodruffe-Peacock states that when in good health hares swallow enough moisture off the grass to quench their thirst, but when sick they are great drinkers at ponds or streams.

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[1] Woodruffe-Peacock, *op. cit.*, 13; see also Drane, *op. cit.*, 106.

[2] See Harding Cox, *Field*, 22nd September 1906, 540.

[3] *Loudon's Mag. Nat. Hist.*, v., 1832, 99.

[4] *Birds of Iona and Mull*, ed. J. A. Harvie-Brown, 1890, 72.

[5] *Zoologist*, 1844, 420.

[6] *Cf.*, for rabbits, E. T. Booth, *Field*, 6th Oct. 1883, 490.

[7] As *Field*, 1889 (many references); F. Newbolt, *Journ. cit.*, 18th October 1890, 599; W. L. Distant, *Zoologist*, 1904, 187.

[8] *Op. cit. supra*, p. 270; also MS. per T. W. Proger.

The pitiful screech of a wounded or frightened hare is well known, and has been likened to the cry of a child; the horror of hearing it has caused not a few sportsmen to give up shooting these rodents. But, apart from this penetrating scream of anguish, few people appear to have heard their voice, and most naturalists credit them with being very silent mammals. If this be the case, it is probable that the silence is due not to inability but choice, for the Irish Hare possesses no contemptible vocabulary, and it is unlikely that in this respect it is inferior to its larger relative.

Besides their cries of pain or distress, hares are capable of uttering other sounds. Inasmuch as these are seldom heard[3] and are known only to close observers, it seems well to quote freely from the few writers who have described them; their accounts do not agree in all respects. Mr Drane,[4] after many years' experience of tame hares, distinguishes the cry of sudden fear from that expressing pain. Both sounds are emitted with open mouth, and resemble the word "annt" or "aunt" reiterated. Mr Drane believes that this is the only open-mouthed voice of the hare. But it utters with closed mouth other sounds or grunts having a variety of meanings, and which resemble the human "don't," "ōōnt," and "ŏnt." Mr Drane could always make his pets say "don't," by threatening them with a quick movement of the hand, as if to seize them suddenly, they being so tame as to know that no harm was threatened. The exclamation is clear but not loud, and, indeed, often only just audible. The same sounds were described by Cornish[1] as "a kind of grunting squeak," and by Mr Woodruffe-Peacock as a "snuffling grunt," which is the accompaniment of a fight—"a peculiar grunting and hissing sound, produced by the throat and lips together."

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[1] *Zoologist*, 1867, 604.

[2] *The Hare*, cit. supra, 27.

[3] Charles Darwin, for instance, remarks (*The Expression of the Emotions in Man and Animals*, 1872, 83) that "Hares and rabbits . . . never, I believe, use their vocal organs except in the extremity of suffering"; but in a note to Francis Darwin's edition of 1901, 88, the author is stated to have subsequently received information that hares cry to their young.

[4] MS., and *Field*, 25th March 1905, 504.

The guttural pipe of the doe and the minor key of her sucklings are noticed by Mr Woodruffe-Peacock as well-known sounds of evening and early morning where hares abound. These cries appear to have been first written of by Edward Jesse.[2] That of the dam he considered faint, and somewhat like the feeble bleat of a fawn; the leverets answer in still feebler tones. The mother's call has been mentioned also by Mr Drane and Mr Millais. The latter's information was obtained from a keeper, who informed his employer, Sir Richard Graham, that this peculiar cry—"something between a grunt and a whistle"—can be heard distinctly at a distance of three or even four hundred yards. According to this man, the doe follows the scent of her young just like a dog, and utters this curious call as she goes along, and a similar one when she wishes to summon her litter to her side. Mr Drane's description is slightly different, for he states that the expression "ōōnt" was emitted rather than uttered by his pet hares to their young when loose at night in his house; it was so very subdued that to hear it at all an observer must be at very close quarters. The discrepancy may have arisen from the natural differences between observation in a house and out of doors.

Mr Woodruffe-Peacock describes a warning sound produced by the grinding together of the teeth. It is passed on from hare to hare over a wide area, and puts every individual within hearing on the alert for danger. Its effect is like the stamping of the hind feet amongst rabbits.

There are also "the low and plaintive tones," as they have been called, of the amorous buck and doe, which, together with the sounds already described, are so well known in the country to those who spare the time for quiet watching, that no one seems to have considered an accurate description of them worthy of being committed to paper. Otherwise a recent discussion on hare-calling, or "hare-sucking," as it is often called, would never have been deemed necessary. With the advent of modern firearms and the general decay of methods involving time and patience, hare-sucking has certainly fallen into disuse in England. But it is well known to gamekeepers and poachers, and the best proof of its existence is that hare-calls may be purchased at the present day from many gunmakers.[1] In March 1910, two men were convicted in the north of England for killing six buck hares by the use of such a call,[2] and the practice undoubtedly survives commonly amongst poachers in other localities.[3] The bucks are usually enticed by an imitation of the cry of a doe, but it appears that the scream of a leveret in distress may also be used. Calling hares requires some little skill and a precise interpretation of the sound to be imitated. A blade of grass properly manipulated is far more effective than a purchased call used without knowledge, for hares seem to be more discriminating than rabbits, which can be attracted by very careless calling.

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[1] *Op. cit.*, p. 156.

[2] *Scenes and Occupations of a Country Life*, 1853, 310, as pointed out by Harting, *Field*, 4th March 1905, 375; see also *The Hare.*

Outside Britain the calling of animals by imitation of their cries, is, especially in the sexual season, very prevalent. Hares are thus killed in Arctic America;[4] in France, where, according to Mr Harting, the poachers make use of an ivy leaf; as well as, in former times at any rate, in Greece.[5] In North China, according to Mr M. P. Anderson, the Common Hare[6] of Chefoo "is not wild, but will stop again and again if one whistles sharply." In Germany the cry of a suffering hare is used to attract foxes within gunshot,[7] and experts have learnt to imitate the voice of a leveret or the deeper notes of an old hare by blowing through their hands.[1]

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[1] As Westley Richards of Birmingham. A variety of calls for birds and animals were figured in the *Shooting Times and British Sportsman*, 26th Nov. 1910, 18.

[2] *Field*, 23rd April 1910, 733, where will also be found a summary of the printed information available in regard to the voice of hares and the use of the hare-call.

[3] It is "common enough" (Woodruffe-Peacock *in lit.*).

[4] E. A. Preble, *North Amer. Fauna*, No. 27, 1908, 200.

[5] Richard Chandler, *Travels in Greece*, 1776, 128, records the slaughter of eleven thus called, including "a female big with young."

[6] *L. swinhoei* of Thomas, see *Proc. Zool. Soc.*, London, 14th January (published June) 1908, 10.

[7] Henry Scherren, *Field*, 20th March 1909, 510, and 27th November 1909, 974.

The instrument known as a hare-pipe has a somewhat interesting history. It is mentioned in statutes dealing with sport from at least the year 1389 to 1831;[2] and most writers on sport and natural history, as, for instance, William Bingley,[3] appear to have taken it for granted that it was simply a hare-call, as described above. J. O. Halliwell, however, defined it as "a snare for hares,"[4] and illustrated it by the following quotation:[5]—

> "The next tyme thou shal be take;
> I have a hare pype in my purse,
> That shall be set, Watte,[6] for thi sake."

That Halliwell was right is shown by an entry found by Mr Walter Rye[7] in the Court Rolls of Burnham, Norfolk, that in the 24th year of the reign of King Henry the Sixth (1445) certain individuals were presented for, amongst other things, using snares called "hare pypes." Again, in a Middlesex ordinance of 1512,[8] prohibiting the capture of hares in nets or other engines called "Harpipes" until the Feast of St George (23rd April), the hare-pipe is compared with, but clearly distinguished from a net. Scherren[9] drew attention to an old description of a hare-pipe,[10] which leaves no possible doubt as to its true nature. It was a noose, pegged at one end to the ground, and differing only from an ordinary snare in having a hollow stick or pipe of elder wood threaded on it, so that when a hare thrust its head into the noose and began to struggle, the pipe was drawn up to the throat, causing strangulation.

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[1] Scherren, *Field*, 12th February 1910, 290.

[2] 13 Richard II., stat. i., c. 13, to 1 & 2 William IV. c. 32, when previous game laws were repealed (Harting).

[3] See also E. D. Cuming, *Field*, 6th May 1905, 762, quoting from William Taplin's *Sporting Dictionary*, i., 394, 1803.

[4] *Dict. Archaisms and Provincialisms*, ed. 6, 1904, 434.

[5] *Op. cit.*, 406, under *Go-Bet*, from MS., Cantab. Ff. v. 48, f. 110.

[6] An old name for a hare; see above, p. 253.

[7] *Field*, 13th June 1908, 982.

[8] E. T. Howson and G. T. Warner's *Harrow School*, 1898, 6.

[9] *Field*, 1st April 1905, 557; 20th April 1907, 647.

[10] By L. M. (= Leonard Mascall), in *A Booke of fishing with Hooke and Line*, printed by John Wolfe for Edward White, in Paules, 1590, 62, also figure.

There is no recent record of the use of such a snare, except the statement by Mr Robert Warren[1] that it was employed in County Cork, Ireland, within his memory, for the capture of rabbits, and was set, not in the open like an ordinary snare, but at the mouth of a burrow.

Hares do not pair, but breed promiscuously, the females when they are about four months old, the exact date depending on the date of their birth, but in any case before they are fully grown; definite and reliable observations are, however, a desideratum. The does are discovered and chased by the males by scent, often "to the point of utter exhaustion or death,"[2] and probably, like the cuckoo, dispense their favours with impartial polyandrism. Thus are explained the proverbial combats of the enamoured males, and the strings of "mad" hares which follow their leader in the breeding season, Mr A. H. Cocks having seen seven bucks pursuing a single female.

When in full rut, nothing could be more insane than the infatuated buck. His antics are often extraordinary, and include grunting, biting with ears thrown back like those of a vicious horse, kicking (as he jumps over his adversary, like a barn-door cock), bucking (strange, writhing, upright leaps into the air), and boxing with his rivals. It is true that such combats are rarely of a serious nature, and that they usually cease after March, although the sexual season does not; but for a time the fur flies freely, and Charles Waterton described a long contest which ended fatally for one combatant.[3] Mr Drane was also witness of a savage and fatal affray, during which one hare jumped over the other and disabled it with a blow from its hind feet. It then turned round, sat up and played on the dead body with its fore feet, the strokes of which resounded like those of a muffled drum.[4] A buck has been known to become so blind to the outer world as to pursue

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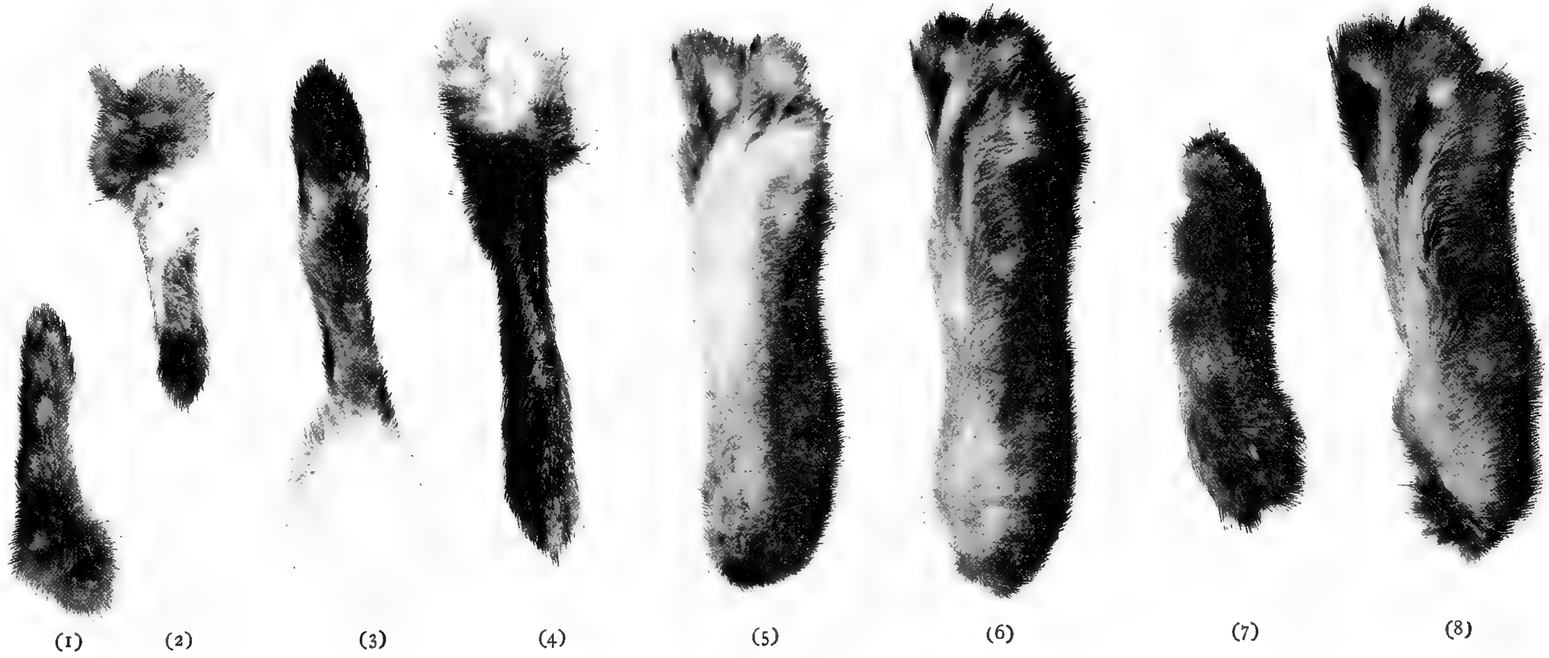
[1] Who sent a specimen to the editor of the *Field*, 11th May 1907, 775.

[2] Owen Jones and Marcus Woodward, *A Gamekeeper's Notebook*, 1910, 57.

[3] *Zoologist*, 1843, 211; another fatal conflict between two bucks is described by A. H. Beavan, in *Animals I have Known*, 1905, 59.

[4] All *Leporidæ* are facile with the feet, which they use a great deal to express emotions, anger or excitement being denoted by stamping; this habit will be found described in more detail in the article on the "Rabbit," see above, pp. 218 and 227, also 168.

PLATE XIX.



Feet of British Leporidæ.

(1) *Oryctolagus cuniculus*, left fore foot, anterior view; (2) Ditto, posterior view; (3) *Lepus europæus occidentalis*, left fore foot, posterior view; (4) Ditto, anterior view; (5), (6), (7), (8) Left hind feet of *L. hibernicus*, *L. europæus occidentalis*, *O. cuniculus*, *L. timidus scoticus*, respectively.

All reduced, the actual lengths having been, as photographed: (1) and (2) 117 mm.; (3) and (4) 193 mm.; (5) 143 mm.; (6) 150 mm.; (7) 101 mm.; (8) 159 mm.

a dog in mistake for another hare;[1] and militants, perhaps of both sexes, when disturbed from their forms by cattle, have had the impertinence to strike the intruders on the nose with their paws.[2] A buck's demeanour, even when not absolutely "mad," always tends to be eccentric, and his excitable actions, sniffing of the ground, and usually in the rear position of a party, often betray him to an initiated observer.

As an instance of precocious pugnacity Cornish's account[3] of a tiny leveret may be cited; it was one of five found together, and therefore new to the world, yet it repeatedly sat up and struck at a stick with its fore paws.

Although the term "mad as a March hare" fully expresses the popular idea of the commencement of the sexual season,[4] this period in reality begins very much earlier, probably in November or December, waxes furious in March, slackens after May, but continues in milder form until July, when it ceases for the autumn. But young leverets have been found in every month of the calendar, so that the hare, which is evidently polyœstrous, may be said, locality and climate suiting, to propagate its species all the year round.

It is impossible to say how many litters are brought forth by each doe during the twelve months, but the fact that young may be found throughout the year makes it unlikely that there can as a rule be less than two or three.

The period of gestation is usually stated[5] to be thirty days, which would be the same as that of the Rabbit. But, having regard to the distinction in size between the two animals and the marked difference in the stage of development reached at birth, it is probable that the period of forty-two days mentioned by some writers is more nearly correct.[1]

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[1] E. D. Cuming, *op. cit.*, 34. [2] Cornish, *op. cit.*, 156. [3] *Op. cit.*, 157.

[4] "The Master of Game" (*op. cit.*, 20-21), translating from Gaston de Foix, has some good remarks on the breeding habits of hares:—"The hares have no season of their love for, as I said, it is called ryding time, for in every month of the year that it shall not be that some be not with kindles [young]. Nevertheless, commonly their love is most in the month of January, . . . and from May unto September they be most slow, for then they be full of herbs and of fruits, or they be great and full of kindles, and commonly in that time they have their kindles. . . . A Hare beareth commonly 2 kindles, but I have seen some which have kindled at once sometime 6, sometime 5 or 4 or 2" [error for 3].

[5] *E.g.*, by E. R. Alston (in Bell), MacGillivray, Jenyns, Blaine, Bingley, etc.

The young are born covered with hair, with the eyes open, and are capable of running[2] soon, if not immediately after birth. No special nursery is prepared, nor does the mother pluck down from her underside, as do the Common Rabbit and the Snowshoe Rabbit[3] of North America. When newly born the whole litter may be found huddled together, often with the mother. But this is only for a very short time; soon each squats in a miniature form by itself. At night they are ministered to by their dam, but whether she takes the active part in their dispersal, described below by Mr W. D. Dovaston, or whether they scatter naturally and of their own initiative, is still a debatable question. Probably, also, once the shelter of darkness has fallen over them they do not wait for their mother to visit them; at all events, young leverets, if taken to a house, are very active at night.

Superfœtation must be rare, as it is difficult to obtain satisfactory evidence of it; and in some cases the facts may be explained as indicating only delayed development. A doe described[4] by Dr Cuthbert Johnson contained two lots of young; a single one with hair and open eyes, and three others bald, pink, and about the size of full-grown mice. Captain Mayne Reid writes[5] of another doe suckling two sets each of two young, but of different age, at the same time; but as the incident was not observed by himself, confirmation of the existence of such a practice would be desirable. Knowledge on these points is very meagre; but, if the period of gestation is forty-two days, if the young depend on their mother for three weeks, and if the doe, like the rabbit, pairs again shortly after parturition,[6] then one litter should be off the dam's hands sometime before the birth of the next. If the period of gestation lasts only for thirty days, then one litter would run more closely on the heels of its predecessor.

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[1] Woodruffe-Peacock (*op. cit.*, 6) gives it as thirty to forty-two days; and T. Speedy, *Field*, 13th September 1902, 492, as forty-two.

[2] The mature fœtus measures 155 to 200 mm. to end of hind legs (Cocks, MS.).

[3] *Lepus americanus*; see Thompson Seton, i., 631.

[4] See above, p. 168; *Field*, 5th May 1883, 605; another instance is given by Speedy, *loc. cit. supra.*

[5] *The Naturalist in Siluria*, 1889, 149-150.

[6] This is the old, and probably correct, belief, dating at least from Aristotle:—"The female . . . after bearing submits immediately to the male" (*Historia Animalium*, ed. Thompson, vi., 33, 580^a, 3).

Judging from the habits of the Irish Hare, the maternal feeling rapidly weakens, and D. P. Blaine[1] saw "what we believe to be the mother, driving a leveret or two away from her." For the short time[2] that the young remain with the dam she is an anxious mother, remaining in their vicinity, removing them in her mouth if discovered, and, if necessary, so far forgetting her timidity as to charge and drive away intruders. Mr G. Eames,[3] then Master of the Cotley Harriers, Chard, vouched for an instance when a doe ran round a man who had picked up a leveret, grunting and stamping her displeasure until it was released; and Mr Walter[4] relates that he was once charged three times by a hare, her conduct being explained by the discovery of a leveret lying a few yards away. The killing of a rook by a hare at Lockerbie, Scotland, was no doubt also due to a fit of maternal fury.[5]

An observation of Mr W. D. Dovaston's is that when leaving the young the doe makes one big leap, covering as much as fifteen feet when measured on the snow.

It is probably the early dispersal of the newly born leverets that has caused hares to be usually regarded as not very prolific animals.[6] Most observers have met with small numbers of leverets together up to at most four; but larger litters of five, six, or even more, have been occasionally reported.[7]

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[1] *Encyc. of Sport*, 1875, 508.

[2] Daniel (*op. cit.*) wrote that it would not be possible for the mother to suckle her young for more than a short time, or her udder would be too big. Whether this suggestion be true or not, it is obvious that the shortest possible suckling period would be the most satisfactory.

[3] *Field*, 16th May 1908, 831; for a similar instance, see John Wilkes, *Field*, 22nd October 1892, 613.

[4] *Op. cit.*, 177.

[5] J. Cumming MacDona, *Field*, 2nd June 1883, 742.

[6] In order to survive a hare *has* to be prolific, for all carnivorous beasts and birds kill it or its leverets when they get a chance, and, except in defence of its young, the idea of resistance never seems to enter its head. But Blaine's statement (*op. cit.*, 508), that a single pair enclosed in a walled garden had increased after twelve months to fifty-seven, is incredible, and evidently an exaggeration.

[7] The following records of over five at a birth are worth preserving, but it would be too much to say that all are authentic—six in one form, Elchies, Strathspey, Elgin (Scotland), photo sent to editor by C. Harrison, *Field*, 8th December 1906, 991; six embryos, Norfolk, C. T. Robinson, on the authority of his father, *loc. cit.*; six, Kent, R. Pembrook, *Field*, 12th August 1893, 245; six (with exhausted mother),

The *Leporidæ* attracted the attention of Herbert Spencer when elaborating a theory[1] to explain the relative degrees of fertility in the different races of men and animals. He believed that hares and rabbits illustrate the effects of different degrees of activity upon fertility, the two animals being similar in their diet, but unlike in their expenditure for locomotion. According to Spencer's information, the relatively inert rabbit has six young ones in a litter and four litters a year; while the relatively active hare has but two to five in a litter. That is not all. The rabbit begins to breed when six months old, but a year elapses before the hare begins to breed. These two factors compounded result in a difference of fertility far greater than can be ascribed to unlikeness of the two creatures in size. The value of Spencer's generalisation as compelling thought is not seriously impaired by reason of the errors in certain details; but its application in a wide sense to all mammals is problematical.

Some interesting observations were carried out by the late J. F. M. Dovaston, of West Fulton, Shropshire, who died in 1854, and whose description of the habits of the Water Shrew has already been quoted.[2] Unfortunately, although his experiments were continued by his son, nothing was published on the subject until Mr Forrest[3] obtained an account of them from his great-nephew, Mr W. D. Dovaston, of Shrewsbury. The elder Dovaston kept a number[4] of hares in the comparative freedom of a piece of grassland, enclosed with wire, near his house. The animals bred freely, and the number of young born at a time was found to be almost always five. Soon after birth the mothers were seen to take them one by one in their mouths and deposit them in separate places in the paddock, subsequently visiting them each in turn to feed them. Mr W. D. Dovaston is personally in a position

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Hampshire, B. V. H. Forder, *Field*, 19th August 1893, 322 (found by C. Coote); six, photo of received from J. W. H. Grant, with *lit.* of 9th August 1906; seven, newly born, in one form, Gloucester, J. Garne, *Field*, 7th July 1888, 6; see also *Daily Mail*, 1st May 1906 (not seen, *fide* Millais); eight crouching in a bunch under a heap of hedge-trimmings, Owen Jones, *A Gamekeeper's Notebook*, 1910, 66; nine, "all of equal full size," Daniel, *Rural Sports*, iv., 1801, 695.

[1] *Principles of Biology*, revised ed., ii., 1899.

[2] Above, p. 137.

[3] *Field*, 6th September 1902, 452.

[4] The number of does is not stated, and W. D. Dovaston was unable to enlighten Forrest on this point.

to vouch for the accuracy of the particulars, since, when a boy, he was in the habit of going round to find where the does had put the leverets. There is no reason to doubt Dovaston's observations, which have, indeed, been frequently confirmed both as to the number of young, and in respect to the doe carrying her young like a cat.[1] But Mr Forrest goes too far when he assumes that the number of leverets is always, or even most frequently, five. In fact, a no less weighty authority than Dovaston, the late J. C. Mansel-Pleydell,[2] laid it down that, although his keeper once found five together, three is the most usual number with vigorous mothers, but with old does only two, and with young mothers one; and these smaller numbers were verified by dissection. There can be little doubt that in the case of such prolific and flexible animals as the rodents, the number of litters and of the young in each must undergo considerable variation[3] in accordance with the prevailing conditions of food, weather, and the health and age of the animals themselves[4]; Brehm states that the number of young in the first litter is one or two; in the second it may reach three or four; in the third, three; and in the fourth, one or two. It is probable that the number of leverets in a litter decreases proportionately with the number of litters produced by the dam in the year. The largest litters might, therefore, be expected in the north, where the climate reduces the length of the breeding season. This may explain why the species of hares inhabiting the barren northern districts of North America and Greenland commonly give birth to eight, nine, or ten young at a time.[5] But in these northern hares the mammæ are more numerous than in the Brown Hare, so that they would have less difficulty in rearing a large family.

This species has now and then been kept as a pet, but must be taken young to become absolutely trustful. If kindly treated, it may then become so affectionate and confiding as to render the term captive inappropriate.[1] It has pretty, cat-like ways of cleaning itself, and is in every way a most engaging animal, full of life, activity, and inquisitiveness, but rather large for convenience, and requiring more space and attention than can be spared by ordinary people. In fact, the playful but boisterous habit of climbing all the furniture in turn, so that nothing was out of its reach, caused Mr Cocks to banish an otherwise delightful pet to an out-of-door cage; and one belonging to a lady of my own family met the same fate, owing to its aggressive attacks on strangers and its noisy nocturnal activity. Hares may be taught to play all sorts of curious tricks,[2] and to appear as performers in public shows. They will associate freely with, and are at least a match for, domestic cats and dogs,[3] but often meet their end owing to attempted liberties with strange dogs, as did one which lived with a butcher in the town of Alloa, Clackmannanshire.[4]

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[1] Editor of *Field*, 7th November 1891, 706; and 1st December 1906, 948.

[2] *Zoologist*, 1888, 259.

[3] The variability is shown by Cocks's observation (MS.), that of seven pregnant females examined at Poynetts, near Henley-on-Thames, six contained a single embryo and the seventh five.

[4] See on this point Preble's account of the American Varying Hare (*op. cit.*).

[5] See above, pp. 160 and 170.

The love of drumming mentioned above is highly characteristic, both of hares and of rabbits, which often sit upright on their haunches and vigorously vibrate their forearms, beating the air with a motion somewhat distantly resembling the action of a man practising boxing. There are frequent intervals in the performance, during which the paws are licked and cleaned, and one of them may be placed in a feline-like manner flat on the breast, palm inwards.

A classical instance of tame hares is that of the poet W. Cowper, whose description[5] of the ways of his three pets, Bess, Tiney, and Puss, is still well worth reading, but is too long to transcribe. The three had quite different characters, and assumed a varying degree of tameness. One died soon after attaining maturity; the second reached nine years before succumbing, as was supposed, to an accident; but the third died of sheer old age at one month short of twelve years.

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[1] The leverets may be reared on cow's milk, or suckled by a cat. Woodruffe-Peacock states that they require fairly coarse sand for grinding down their teeth (*op. cit.*, 13).

[2] E. C. Phillips, *Field*, 26th July 1902, 183.

[3] C. Wapshare, *Field*, 3rd January 1891, 10.

[4] P. Anderson Graham, *Country Pastimes for Boys*, 1908, 226.

[5] *Gentleman's Magazine*, June 1784, 412; epitaph on "Tiney," *Journ. cit.*, December 1784, 935.

These three were all males, and were given no opportunity of breeding. As a matter of fact, hares are very infertile if kept in close confinement, but the reverse is the case if a small grass run is provided. Mr Drane's hares produced two litters, but they had the unrestrained freedom of his house at night. A pair confined in a small run measuring only fifteen by six feet produced young as follows: in 1901, three in two litters; in 1902, two in two litters; in 1903, four in three litters. In 1904 the doe hare died.[1]

Mr Drane, who has written a most sympathetic and appreciative account[2] of his pet hares, states that they panted for pleasure like dogs, and, again, like dogs also, dreamt in their sleep. Some of their dreams must have been as unnatural as those of the human species, for they were accompanied by actions suggestive of burrowing,[3] a practice to which they are little addicted when awake. Of the attitudes of the hare he writes, that "they are very striking and bewitchingly graceful. It will sometimes lie at full length on its side, with its head only erect, its hind legs stretched out to their full length. In this position its white underside, otherwise but rarely seen, is very conspicuous, and as the back may not then be visible, the creature looks mainly pure white, with *blue* or French grey ears, for the inside of the ear is very blue at times. It will romp and roll itself with infinite delight and sprightliness on a clean, white counterpane or table-cloth. Sometimes it will sit with its hind legs extended forward, so that the hind feet are in advance of the nose, when it looks as if it had four fore feet and no hind ones. Again, it will draw back its hind feet and extend its fore ones to their fullest length, and then its head seems to rise from the centre of the back. But perhaps the prettiest thing of all is to see it clean its ears. It puts its head on one side, pulls down its ear, and passes its two paws over it again and again most strikingly, like a lady dressing her hair.

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[1] T. Thompson, *Zoologist*, 1904, 470. For other instances, see John Ditch, *Field*, 17th May 1890, 733.

[2] *Op. cit. supra*, p. 270.

[3] In this point Drane may have been mistaken, since the motion of the hare's forearms may have been the result of thoughts other than of digging; there is no evidence that the ancestors of hares were burrowing animals; even in the case of the Rabbit the evidence is all the other way.

It can stand quite perpendicular, without support, upon its hind toes, and even advance some steps in that position, balancing itself by holding out its fore limbs horizontally. Its leaps are remarkable for their height, grace and agility. It habitually overleaps its object, and comes down upon it with a curved descent, as beautifully as an antelope, thus contrasting with the cat, which scarce jumps up to the necessary height, while the hare overleaps it. I question whether it ever *runs* with its hind legs. . . . Its ordinary habit is to walk and run with its fore legs, and only to hop with its hind.

"In its disposition it is pacific, trustful, and affectionate in a most touching degree when its heart has been gained, and indeed even when it has not. My hare will always lick my hand in response to a caress, and by the same habit silently appeal to me for protection in any apprehended danger, as the presence of a stranger, or of some person whom it distrusts or dislikes."

The various methods of cooking hares' flesh would probably fill a fair-sized chapter in a volume on cookery, and have no direct concern with the present article.[1] It would, however, be hardly complete without allusion to two such celebrated dishes as hare soup and jugged hare. Colonel Kenny Herbert has written a delightful chapter on this at first sight unpromising subject, and it may be recommended to the curious.[2]

GROUP LEPUS.

An attempt was made by Lyon (see above, p. 229) to separate the American varying hares sub-generically, but the definition of his sub-genus POECILOLAGUS contained no absolutely diagnostic skeletal or other structural character. On the other hand, the varying or snow-hares of the Old World, together with *L. arcticus* and its allies of North America, form a natural and easily recognisable **group**, distinct not only in structure, but in origin and habits from the hares of the group *Eulagos*.

History:—Snow-hares have been occasionally alluded to at least from the time of Varro (B.C. 116-27), who described (*De*

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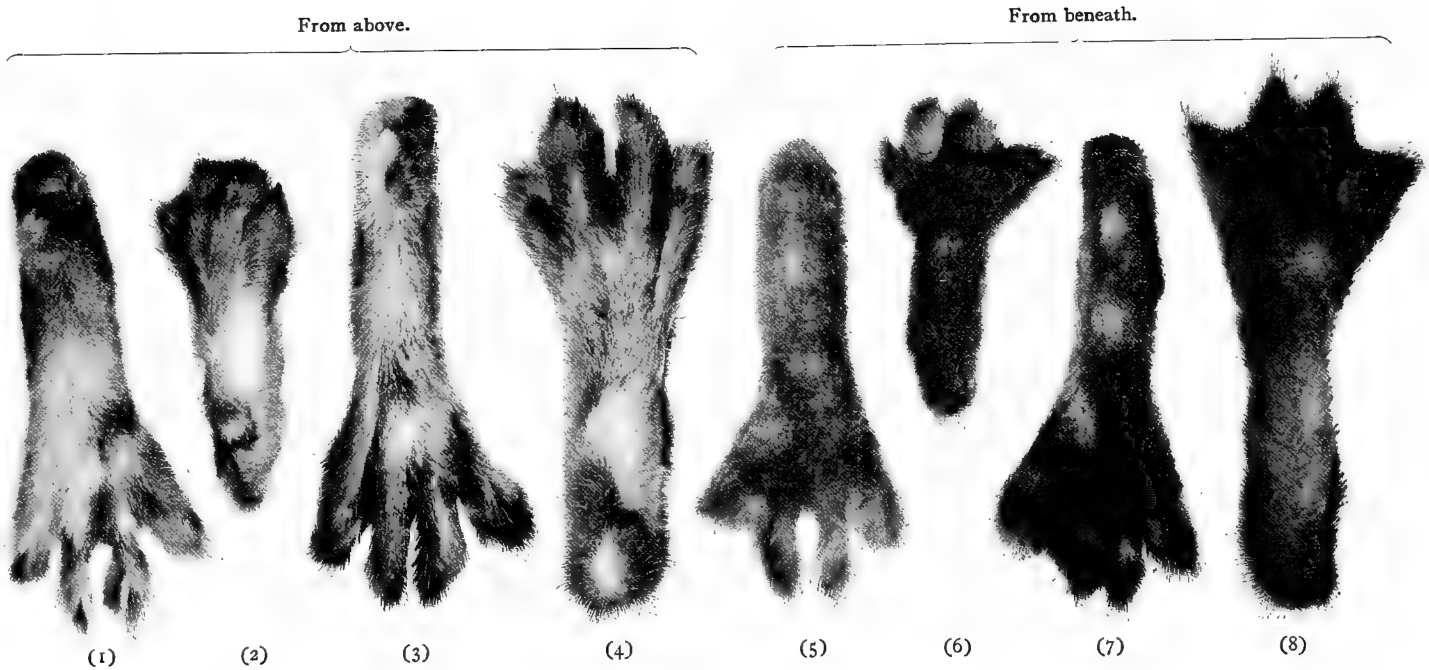
[1] See Cocks, 171.

[2] *The Hare*, 231-262.


From above.
From beneath.
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)

Hind Feet (Left) of British Leporidæ.

(1) and (5) *Lepus hibernicus*, reduced from 143 mm.; (2) and (6) *Oryctolagus cuniculus*, reduced from 101 mm.; (3) and (7) *L. europæus occidentalis*, reduced from 150 mm.; (4) and (8) *L. timidus scoticus*, reduced from 159 mm.

Re Rustica, iii., xii.) the Alpine form, which Miller has appropriately named *L. timidus varronis*, in the following words:—"Alterius generis est, quod in Gallia nascitur ad Alpes, qui hoc fere mutant, quod toti candidi sunt," *i.e.*, "there is another kind, which is found in Gaul on the Alps, which make this change that they become totally white." They were also noticed by Pliny, who wrote in the first century A.D.; he mentioned their seasonal changes of colour, and stated that they eat snow for food. They are, however, said to have been regarded as rarities at Rome in the same century, and to have been brought into the circuses in the reign of the Emperor Nero (Keller, 213). In spite of the fact that they were specified as existing in the Orkneys in the twelfth and again in the sixteenth centuries (see below, under *L. t. scoticus*), they seem not to have been accurately known to zoologists until comparatively recent years; and this fact accounts (as shown above on p. 251) for the confusion which has arisen over the technical names of European hares.

Externally, these hares are **characterised**, as compared with *L. europæus*, by their relatively large head, prominent eyes, less highly developed olfactory apparatus and whiskers, shorter and narrower ears, shorter tail, longer limbs, especially the fore, and relatively larger feet. The coat is woolly, with distinct pattern of the underfur, and there are marked juvenal and post-juvenal pelages; the tail is wholly white, and there is a conspicuous spring moult. There are eight **mammæ**, of which a pair are pectoral and three pairs abdominal.

In the **skull** the brain-case is relatively broader and shallower; the frontal region is concave behind the nose, anteriorly less constricted and broader behind the superciliary processes, which are raised above the level of the skull in connection with the large eyes. As a result, the dorsal profile is not conspicuously arched, and barely rises above the anterior roots of the zygomata. The anterior portion of each zygoma is relatively deeper, the distance from the anterior termination of the groove on the outer surface to the front edge of the arch being less than the least depth.

In the **teeth**, the upper incisors are slightly narrower as well as straighter, and their roots extend beyond the premaxillo-maxillary sutures, where they terminate in marked swellings on each side of the palate. The cheek-teeth are longer, the height of a posterior upper premolar, measured from crown to extreme upper point of the root capsule, within the orbit, being greater than the alveolar length of its tooth-row.

The **mandible** is characterised by its relatively large dimensions of height, a consequence of the more hypsodont teeth. Its inferior border is rounded, not sharp, and passes insensibly into the symphysial region.

The **scapula** is relatively wider, this feature being more marked in *L. hibernicus* than in *L. t. scoticus.* The tibia attains a much greater length than in *Eulagos.*

The group includes a number of forms of circumpolar **distribution** in Europe, Asia, and North America, but not occurring naturally in Novaya Zemlya, Franz Joseph Land (Bruce), Spitzbergen (Collett), Iceland, or the Faeroes. Two pairs from Norway were turned down in 1854-55 at Stromö, in the latter islands, and their descendants are stated to have increased so rapidly as to have numbered thousands after a very few years (Müller and Trevelyan, *Ann. Mag. Nat. Hist.*, December 1864, 461), and even to have supplied material for reintroductions thence to Norway (Collett).

The exact status of some of the described forms is uncertain, but they may for present purposes be regarded as of specific value; some, as *L. altaicus* and *L. hibernicus*, occupy mountains, or islands, where they are completely separated from their nearest allies. *L. altaicus* (Sanford, *Quart. Journ. Geol. Soc.*, London, xxvi., 1870, 127), described from the Altai Mountains, is a reddish-brown hare, resembling *L. hibernicus* in colour, but with the black ear-tip extending downwards to the base of the ear; *L. ainu* (Barrett-Hamilton), described from Yezo, Japan, has a large narrow skull, the occipito-nasal length of which reaches 97 mm.; Nordquist's *L. tschuktschorum*, of north-eastern Siberia, is even larger than the last, with occipito-nasal length of skull 103 mm.; Allen's *L. ghiciganus*, described from Ghiciga, Eastern Siberia, is smaller, tawnier in summer, and with less massive skull and teeth. Undescribed hares of this group occur in Sakhalin Island (see Thomas, *Proc. Zool. Soc.*, London, 1907, 414), as well as in the Stanovoi (see Allen, *Bull. Amer. Mus. Nat. Hist.*, New York, xix., iv., 31st March 1903, 157) and Khingan Mountains, Northern Manchuria (Thomas, *Ann. Mag. Nat. Hist.*, December 1909, 504).

There are two living **British species**, the Irish Hare, *L. hibernicus* and the Scottish or Blue Hare, a sub-species of *L. timidus*, the range of which latter, regarded as a species, includes all arctic Europe to an unknown point in corresponding latitudes in Siberia. In Norway it has, according to Collett, a wider distribution than any other game animal, being more or less frequent from the seashore to the edge of the snow on the fjelds; in the islands, however, it is unevenly present and apparently not native, though it usually thrives well where introduced, despite the attacks of its chief enemies, the sea-eagles and eagle-owls; it occasionally visits Denmark, by crossing the ice from Skåne in Sweden. In Finmarken it reaches the extreme north of the mainland, but is rare on the furthest coastline (Collett). In Russia it ranges south to 55° N. lat., and is found in West Prussia and Lithuania (Blasius). It has an isolated colony in the Alps (*L. t. varronis* of Miller), but has been incorrectly credited to the Pyrenean fauna (see Trutat, *Bull. Soc. d'Hist. Nat.*, Toulouse, xii., 1878, 110); there is a doubt also if it occurs in the Caucasus.

Distribution in time:—Although remains of hares are plentiful in British and west European deposits of late pleistocene age, all those that have been satisfactorily determined belong to some form of true *Lepus;* the group *Eulagos*, as has been already shown on p. 259, being entirely unrepresented. The varying hares were widely distributed in late pleistocene times, and ranged to the south of England, and in continental Europe as far south as Parignana, Italy (Forsyth Major, *Atti. Soc. Sci. Nat. Ital.*, xv., 390). They are thus shown to be older, and the brown hares newer inhabitants of the country.

Hinton showed that the fossil skulls from the late pleistocene deposits of Ightham Fissure, Kent (*op. cit. supra*, p. 259), belonged to animals resembling the Irish Hare, but distinguishable by larger size and robuster skeleton, characters shared by all other specimens from the English Pleistocene. Hinton could not unite any British specimens with fossil hares described from continental localities, the latter either having other affinities, or being, like *L. diluvianus* of Pictet (*Traité Élémentaire de Paléontologie*, 1844, t. i., 207), too imperfectly known for purposes of comparison. Hinton therefore characterised the English pleistocene form of *L. timidus* as a sub-species, to which he gave the name of "*Lepus variabilis anglicus.*" This hare appears to be the slightly less specialised precursor of our present stock of varying hares, standing in the direct ancestral line of *L. hibernicus*, and, if so, cannot logically be regarded as a sub-species of its own descendant. The better plan would seem to be to treat it as a species.

Evidence has recently been forthcoming to show that *L. anglicus* survived in England until historical times. A tibia from the Roman camp of Corstopitum in Northumberland (see above, p. 259) shows the characters of true *Lepus*, and has an extreme length of 152.7 mm., and an interarticular length of 146 mm., a size far exceeding that of any species now found in Western Europe, but agreeing closely with that of Hinton's Hare (extreme length, 154.6 mm.).

The institution of the group *Lepus* makes it possible to compare the **hares of North America** with those of the Old World which may be said to correspond roughly in their grouping. Thus *L. arcticus* and its allies fall naturally within the group true *Lepus*, while *L. callotis* and the black-tailed "jack-rabbits," though lacking the black ear-tips, resemble *Eulagos* in number of mammæ, in their long ears, their black tail, and, less closely, in pelage. Further, the genus *Sylvilagus*, including the New World cottontails, corresponds, as has been shown above, to a certain extent with the Old World *Oryctolagus*.

On the other hand, *L. americanus*, the "Snow-shoe Rabbit," and its allies, while agreeing in pelage and number of mammæ with true *Lepus*, stand alone in other respects and cannot be connected with any Old World group; and a second irreconcilable feature is presented by the white-tailed "jack-rabbits" of the *L. campestris* group, which are intermediate between *L. americanus* and *L. callotis*. Thus, although the various groups correspond to a certain extent, there are so many points of disagreement that it is not possible, except in the case of *L. arcticus*, to unite those of the Old and New

Worlds. There are, however, so many resemblances, albeit so dimly shown, that it seems safe to attribute them to ancestral divisions of great antiquity, which existed in the family before the separation of the two continents, and which have since been obscured by fresh developments in independent directions. This suggestion is borne out by the occurrence of *Oryctolagus lacosti* in the upper Pliocene of France and Italy, thus showing that the Old World *Oryctolagus* is more ancient than *Lepus*, and has existed as such from pliocene times, just as true *Lepus* is, locally at least, more ancient than *Eulagos.*

According to the above view, the American cottontails and the European rabbits may be regarded as two branches of one group, which stands nearer than any of the northern hares to the original ancestor of all the *Leporidæ.* Their white flesh may be regarded as a primitive character, since the meat of leverets is lighter than that of adults ; it is surely of importance in indicating affinity, but in other respects the two branches have developed to very different degrees. Thus, whereas the cottontails have acquired only to a limited extent the habit of burrowing, in rabbits the practice is almost invariable, but, as stated on p. 172, it is unaccompanied by any special modification in a fossorial direction, thus indicating that the art of digging has been acquired in comparatively recent times, in compensation for lack of speed and staying power. In all the *Leporidæ* the power of consuming and digesting a comparatively coarse and innutritious food has been highly developed, and in this respect rabbits are in no way inferior to hares.

Status:—It has been shown above that the varying hares are a relic of an older fauna, hence they probably stand nearer their common ancestor than the brown hares. It is consequently not surprising to find them exhibiting certain resemblances to the still more ancient rabbits, namely, in their skull, their soft pelage, short ears, and even in their greater inclination to burrow a little. But, on the other hand, in every other aspect of their conformation they must be regarded as distinctly the most specialised British hares.

Winge (*Grönlands Pattedyr*, 1902, 358) finds specialisation in their comparatively regular assumption of a white winter coat. Hinton notes further specialisation in the narrower, stronger, high-crowned molars, straighter upper incisors, more powerful masticatory muscles, and in the larger eyes, resulting in heightened superciliary processes[1] and peculiar curvature of the cranium. To the above features may be added the longer limbs, the shorter tail, complicated system of juvenal and post-juvenal pelages, and the greater number of mammæ, resulting in larger (in compensation for fewer) litters of young. There are only three points in which the Brown Hare appears to be the more specialised, namely, in its longer ears, more highly developed olfactory organs, and stronger whiskers. But it has been already suggested that this is only in compensation for its poorer sight, a combination characteristic of a nocturnal animal. Winge's suggestion that the short ears and shrunken nose of true *Lepus* are a result of a cold climate has no weight in the case of the Irish Hare, which has a southern habitat. Having regard to the short ears of the Rabbit, this particular feature is probably a survival of a primitive character.

The work of differentiating the various members of the group *Lepus* further shows that the southern forms, *e.g.*, *L. hibernicus*, and, very markedly, the extinct pleistocene *L. anglicus*, are distinctly more primitive than the more northern, such as *L. t. scoticus.* Apart from their teeth, the humerus and forearm are in the former of approximately equal length, as seen also in *O. cuniculus*, whereas, in more northern forms there obtains the specialised arrangement, whereby, as in *L. europæus*, the radius is distinctly longer than the humerus.

The most specialised of all is *Boreolepus grœnlandicus*, with its always white woolly coat, short ears, strong nails, and protruding incisors; an animal which by no stretch of the imagination could be regarded as ancestral to, or even older than, the British varying hares, especially since, as shown above, *L. anglicus*, the ancestor of the latter, is most nearly allied to the modern *hibernicus* and not to *grœnlandicus*.

There is no evidence to show how the ancestors of the Greenland Hare reached their present habitat. They can hardly have crossed over from Europe, since, as shown above, the Greenland Hare is not at all closely allied to any Old World species. It stands by geographical position farthest away from the centre of distribution of the whole family, and exhibits the highest expression of that specialisation which has its beginning in *L. hibernicus* and *L. anglicus*.

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[1] Note, however, that in this case the elevation of the roof of the orbit is in some measure also due to mechanical raising by the longer roots of the more hypsodont cheek-teeth.

The **origin** of the varying hares of Britain, and the bearing of their present distribution upon former land connections, has engaged a considerable amount of attention. Most writers regard them as animals of northern origin which were driven south by the rigour of the glacial period. They suppose that, when the cold passed away, and their southern habitat became once more temperate, the hares returned north to their original home. A few isolated colonies remained behind; in mountainous regions, the severer climate of which is presumed to have suited them, and in Ireland, which is considered to have become an island before the close of the glacial period, thus cutting off their retreat. The above view is so plausible and at first sight explains so many of the facts, that it was until recent years very widely accepted; but latterly it has been subjected to considerable criticism. Thus Scharff (*Proc. Roy. Irish Acad.*, ser. III., iv., 3, 1897, 470-71; *European Fauna*, 1899, 315; *European Animals*, 1907, 39), while accepting their northern origin, which he further supports in *Distribution and Origin of Life in America* (1911, 10), pointed out that the hypothetical objection of the varying hares to a temperate climate cannot be the cause of their supposed preference for arctic and mountainous regions, since their Irish representative flourishes in a country of mild temperature and comparative absence of snow.[1] Accordingly he suggested that the Brown and Blue Hares are mutually antagonistic animals, the former and stronger of which has prevailed over the weaker. This is, so far as it goes, a reasonable hypothesis, and explains to a certain extent the distribution of the two groups, as it existed before man's interference.

It is no doubt correct to say that the varying hares of Europe and Asia form an ancient group not necessarily of northern origin, and showing no close relationship with the Greenland Hare. They are the descendants of animals formerly of much wider distribution. They may have originated, as Hinton suggests (*op. cit. supra*, p. 259), in Asia, possibly, indeed, in North America, but they have given way before the competition of more generalised immigrants of the same family, before which they have retreated to mountains, to the polar lands, or to isolated districts, where their strong teeth enable them to masticate the coarse herbage. The newer arrivals have not always had time or power to penetrate these districts, which are, besides, not always attractive on account of their severe climate and deficient food supply. This is shown by the fact that the Brown Hare thrives quite well in Ireland when introduced there (see above, p. 258), and more clearly still by recent events in Skandinavia. Brown Hares are not indigenous to that country, which they were evidently unable to reach owing to the intervention of the Baltic, but they have recently been introduced by sportsmen, and, according to Lönnberg, multiply and crowd out the native hares (see above, p. 237).

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[1] Hinton (*Proc. Geol. Assoc.*, xx., 1907, 39, etc.) drew attention to a similar instance in the case of one of the snow-mice, *Microtus lebrunii* of Crespon.

In the present state of knowledge it is difficult to attempt to explain how the Brown Hare ousts the Varying. Scharff (*Irish Naturalist*, 1898, 126) insists on the existence of "a spirit of antagonism" between the two groups, and such a spirit seems to be almost taken for granted by sportsmen who have both on their lands (see *Journ. cit.*, 1898, 69-76); but there can hardly be active antagonism, since the two species mingle freely, and even interbreed where their ranges overlap. Probably it is a simple case of "crowding out" in a straightforward struggle for survival of the fittest. The advance of tillage farming and the progress of deforestation may possibly be a factor in the situation. It was stated to be so in Livonia (Von Loewis, *Zool. Garten*, 1877, 17-20), and in certain parts of North America similar changes have resulted in restriction of the area occupied by the "Snowshoe Rabbit" (*L. americanus*), and a consequent extension of the ranges of the Prairie Hare (*L. campestris*) and of the cottontails (*Sylvilagus*).

In Newfoundland, on the other hand, the Nova Scotian Varying Hare, *L. americanus struthopus* of Bangs, which was introduced in 1864, although a woodland species, is reputed to have caused a marked decrease in the numbers of the Newfoundland Hare, *L. arcticus bangsi* of Rhoades, and the latter is stated to be now restricted to the highest and barest uplands (Nelson, *North Amer. Fauna*, No. 29, 1909, 65 and 92).

Winter Whitening:—Although the varying hares have gained their name from the fact that in winter they don a white coat, this peculiarity is not restricted to them, being found also in all northern forms of hare. *L. europæus* may also whiten in winter, although not so readily as the varying hares.

Various eccentric views prevailed amongst the older writers, from Pliny, who attributed the whitening to the action of eaten snow, to Pennant (*Arctic Zoology*, 1792, i., 110), who maintained that "these animals, at approach of winter, receive a new coat, which consists of a multitude of long white hairs, twice as long as the summer fur, which still remains beneath." Richardson (*Fauna Boreali-Americana*, 1829, i., 218) thought that "the change to the winter dress takes place by a lengthening and blanching of the summer fur" with a complete moult in the following spring. Audubon and Bachman, writing of a caged American stoat (*Quadrupeds of North America*, 1854, 62, etc.), arrived at the conclusion that the colour is lost or regained after the spring and autumn moults, while Coues (*Fur-Bearing Animals*, 1877, 123) assured himself that the alteration might or might not be coincident with shedding of the fur. Merriam (*Vertebrates of the Adirondack Region*) believed that both in autumn and spring there is an actual change of colour in the hairs, governed by the presence or absence of snow, not affected by temperature, and occurring independently of the moults. Von Loewis, writing (*op. cit. supra*, p. 300) of Livonian hares, affirmed the vernal but could not admit an autumnal moult; Schwalbe, who worked on stoats, attributed the changes to two moults.

This was also the view of an anonymous writer in the *Edin. Philosoph. Journ.* (ii., January to April 1820, 191). Of other British writers, excluding Pennant's somewhat fantastic opinion as quoted above, both Jenyns and Fleming (the latter of whom examined the changes in a stoat, see *Edin. Encyc.*, art. "Hybernation," 1817, xi., 387; *Philosophy of Zoology*, 1822, ii., 23) supported a change in pigmentation without actual renovation of the fur either in spring or autumn. All modern observers are in agreement that the vernal replacement of white by brown is due to a moult and casting of the white hairs; the autumnal blanching, on the other hand, is still variously attributed to moult or to actual abstraction of pigment from the hairs. The latter view was taken by Welch (*Proc. Zool. Soc.*, London, 1869, 228-236), and in 1874 by Alston when editing Bell's second edition. It was utilised by Poulton as the chief basis of his theory on variable protective resemblances in vertebrates (see *The Colours of Animals*, 1890, chap. vii.), and was generally accepted until, in 1894, Allen (*Bull. Amer. Mus. Nat. Hist.*, vi., art. iv., May 1894, 107-128) asserted that in *Lepus americanus* both autumnal and vernal changes are accomplished by moult, a view supported by Collett in regard to *L. timidus* in Norway. Allen was not aware if the underfur of American hares is shed in autumn, but Nelson states (*op. cit. supra*, 18) that in these the underfur does not whiten as it does in European forms.

The first British writer to arrive at the truth seems to have been MacGillivray, whose discovery that the pelage is almost always undergoing alteration and renewal cannot be controverted; while his apparently contradictory belief that nevertheless "sometimes the brown hairs themselves, on the application of intense cold, become whitened" (see William MacGillivray's *Life of William MacGillivray*, 1910, 130) has been corroborated by Metchnikoff. The latter, who has since been supported by Tomasczewski and Erdmann (*Münchener medic. Wochenschr.*, 1906, 359), showed (*Ann. de l'Institut Pasteur*, 1901, 865, pls. 13, 14, and *Proc. Roy. Soc.*, London, lxix., 1902, 156) that, in senescence of old men and dogs, large cells, which he named chromophages ("colour-eaters"), issuing from the central medullary parts of the hairs, enter the cortical layers, where they engulph and remove the granules of pigment. The process may thus be classed under the general laws of atrophy of solid portions of an organism. In a later paper (*Compt. rend. Acad. Sci.*, cxlii., No. 19, 7th May 1906, 1024-1028) Metchnikoff reported that the same facts apply to the hairs of *Lepus timidus* and the feathers of *Lagopus albus*, both of which are thus shown to be living structures. He held that the phenomenon is one of a general kind, which would be found present in other whitening animals such as ermines and mountain squirrels. Metchnikoff thus proved that the view frequently expressed that whiteness might be due to bubbles of air entangled in the structure of the hairs is erroneous. Trouessart (*Compt. rend. des séances Soc. Biol.*, lx., 10th February 1906, 271) corroborated Metchnikoff as a result of the examination of ermines and squirrels. He found that after loss of pigment the central medulla of a hair becomes desiccated, retracts, and dies.

The cycle of coat and colour changes undergone in a cold country of comparatively regular climate is different from that which prevails in the milder but uncertain weather of Britain, and this fact accounts for much discrepancy between reports from various localities. As stated above, the existence of the spring moult is undoubted (Barrett-Hamilton, *Proc. Zool. Soc.*, London, 16th May 1899, 598), but careful search for an autumn moult is often unavailing. A Scottish Hare kept alive at Cambridge during the autumn of 1899 by Barcroft, had turned almost completely white by January 1900 (*Proc. Roy. Irish Acad.*, xxiv., B, 11th May 1903, 303-314). But, although it was constantly under observation in a specially constructed cage, no trace of depilation was detected.

I have since found the autumnal moult occurring irregularly in wild specimens of the Irish Hare, but at the same time a number of Scottish Hares were examined in different localities on my behalf, and there was no shedding of hair, so that observation supports MacGillivray's view, that in Britain both moult and withdrawal of pigment may exist side by side. The change of pelage is as irregular as the climate in which the animals live, and is so susceptible to the influence of the weather that, as shown by MacGillivray, although the great annual casting takes place in the spring, there may be a renewal at any season or in any month.

The autumnal depigmentation varies with the locality and the climate. In a cold country of regular seasons it comes on early and is rapidly completed. In a temperate country of irregular weather it begins gradually, lasts a comparatively long time, but may apparently be accelerated by the advent of severe cold, if it occurs before its completion.

In Eastern Siberia a male of *L. ghiciganus* had nearly completed the change by the 1st October (Allen, *op. cit.*, 1903, 156). In Athabasca *Lepus americanus* begins to assume the white coat about 20th September, and the process is finished by 20th October, the young being earlier than the adults (Preble, *North Amer. Fauna*, No. 27, 1908, 203). In North Europe there is much variability according to locality, but in cold districts the winter coat may have been donned in its entirety by the first week of October (Collett). In Scotland the whitening starts in September or October, but is not completed until the middle of November or the beginning of December. In Ireland the blanching, when it occurs, advances in much the same manner as in Scotland, but is extremely variable and usually incomplete. It commences about November, progresses at a gentle rate, and may rapidly terminate in cases of considerable whitening within the first few days of December (*Proc. Royal Irish Acad. cit.*, 306).

The order of change of the various parts of the body from brown to white is not invariable, but, on the whole, both in Europe and America, follows a fairly regular sequence. The feet and legs, the grey parts of the ears and parts of the head, are the first affected. Then follows the rump, and the white area of the under-side creeps upwards, driving the line of demarcation before it, until the brown of the back is extinguished, or remains as an island or islands. Portions of the head may also remain brown. Although the above procedure is more usual, some individuals, especially in Ireland, seem to become gradually white all over, and pale spots often appear in the middle of brown areas. In the spring the order of change is reversed, the brown colour starting on the head and upper back and working downwards. The black ear-tips never alter, not even in the otherwise always white Greenland Hare, probably because the hairs composing them are subject to a single annual moult only; apart from that the process of incipient whitening in the Brown Hare seems to indicate that brown shades whiten more readily than black.

According to Collett, the wool becomes detached later than the long hairs in autumn, but in spring it precedes the hairs; I am not sure that this is correct.

There is some, but not conclusive, evidence that the animals which, where the process is not invariable, turn whitest and remain so longest are females, or old individuals of both sexes. It was probably this feature that led William Thompson to conclude of the Irish Hare that it whitens mainly in parks, where, owing to protection, it can grow old, and that the change only becomes conspicuous after the fifth year. Late-born young are slower to moult than adults.

The spring change is no less variable in date than that of autumn. Even in a country enjoying such a temperate climate as the south of Ireland it may take place at such an unexpectedly late season that it results in the remarkable spectacle of a hare running about in all its conspicuously white arctic livery under the bright rays of a May sun (see Barrett-Hamilton, *Proc. Zool. Soc. cit.*). It must be remembered that this remark refers to one of the mildest parts of the British Isles; but resumption of the pigmented pelage is long delayed also in Scotland and in Wales, where the introduced white hares may be seen until the end of April, or even in May. The same facts apply also in other countries. An adult female of *L. ghiciganus* of Eastern Siberia was still partly in the winter dress on 28th May (Allen, *op. cit.*, 1903, 156), while at Fort Chipewyan, Athabasca, Preble (*op. cit.*, 199) found *Lepus americanus* retaining a few scattered hairs of the winter pelage late in the same month, and in Finmarken the summer dress is not assumed until July (Collett). On the other hand, Coward (*Zoologist*, 1901, 74) saw the fur blowing off the imported Blue Hares of the Cheshire hills in March; and in January 1910 I examined two male Irish Hares in full moult. To illustrate the uncertainty of the moult, in the same year and on the same ground two heavily whitened Irish does retained their winter coat; one of them, a fine animal weighing 9 lbs., until killed on the 9th April; the second was distinguishable by her whiteness well into the month of May.

According to the above account, winter whitening is essentially the same phenomenon in all species exhibiting it. It varies only in details dependent largely on local conditions.

In the extreme north adult hares are white all the year round without variation, the young alone showing traces of a pigmented coat (*e.g.*, in the Greenland Hare, Feilden in Nares's *Polar Voyage*, 1878, ii., 204). In countries where the assumption of a white coat is invariable but seasonable, the length of time for which it is worn is more or less rigidly marked out by long custom apart from the influence of the weather, which cannot greatly retard or hasten the normal sequence of events. Animals captured in such conditions and placed in the shelter of confinement still whiten if they have been accustomed to do so while at liberty, as they do also if removed to a more southern locality, or even, it is said, if kept in heated apartments (Bingley); the latter point would, however, seem to require confirmation.

In temperate countries, as Britain, where the process is either not invariable or frequently incomplete, it is very subject to climatic as well as to other influences, such as sex, age, health; and the result is much variability. In Wexford an individual may be found assuming the white coat in December, and another moulting back to the summer pelage in January. The effect of severe cold in Britain may possibly be observable in the increased whitening which is said to ensue in the subsequent winter, even if it be a mild one.

It is not known how long transported individuals and their descendants will continue to change in a milder climate; Irish and Scottish specimens imported to Mull are said to retain their respective whitening characteristics, but exact details are lacking. The Norwegian hares mentioned above on page 294 as having been introduced into the Faroe Islands are said, with very few blue-grey exceptions, to have whitened regularly at first. Gradually, however, the grey individuals became more numerous and the white scarcer, until, in 1860, out of one hundred shot only five or six were white, the others being bluish grey. Thus, in less than forty years the winter coat had changed its character.

THE MOUNTAIN OR BLUE HARE.

LEPUS TIMIDUS, Linnæus.
LEPUS TIMIDUS SCOTICUS (Hilzheimer).

1758. LEPUS TIMIDUS (species), Carolus Linnæus, *Systema Naturæ*, x., 57 (part); xii., 77, 1766; described from Upsala, Sweden; Lydekker; Thomas, *Zoologist*, 1898, 101; Johnston; Millais.

1778. LEPUS VARIABILIS (species), P. S. Pallas, *Novæ Species Quadrupedum Glirium Ordine*, 2 (part); renaming *L. timidus* of Linnæus; Berkenhout; Turton; anon., *British Cyclopedia*, 704, 1836; Bingley; Fleming; MacGillivray; Clermont.

1770. ALPINE HARE, Thomas Pennant, *British Zoology*, iv., 40, pl. 47 (habits and occurrence in Scotland described); *Synopsis Quadrupedum*, 1771, 250; *Tour in Scotland* in 1769, 1772, ed. Pinkerton, 96; Lightfoot's *Flora Scotica*, 1777, 11, No. 21.

1772. WHITE HARE, Thomas Pennant, *Tour in Scotland* in 1769, ed. Pinkerton, 96.

1781. VARYING HARE, Thomas Pennant, *History of Quadrupeds*, 370; a footnote in Index, xvii., explains the changed name from *Alpine Hare* of the *Synopsis Quadrupedum*.

1808. LEPUS TIMIDUS, . . . β. *L. alpinus*, corpore cinereo-albo, auriculis apice nigris. The Alpine Hare. Scot. The White Hare. Intolerandi rigoris alumnum. Plin. John Walker, *Essays on Natural History*, xiii., 491 and 493 (probably written between 1764 and 1774); described from Scotland—"Locus-Habitat versus cacumina montium Scotiae altissimorum, locis scopulosis. Monte Cruachan dicto in Argathelia, Ben Nevish in Abria, et praesertim montibus in Rossia occidentali, ubi frequentissimus est"; preoccupied by *Lepus timidus alpinus*, Erxleben, *Systema Regni Animalis*, i., 328, 1777, a synonym of *L. timidus*, Linnæus, and by *L. alpinus*, Pallas, *Novæ Species Quadrupedum Glirium*, 1773, an OCHOTONA.

1816. LEPUS ALBUS, W. E. Leach, *Systematic Catalogue of the Specimens of the Indigenous Mammalia and Birds that are preserved in the British Museum*, 7; adopting Brisson's *Lepus albus*, named, but without description, from Scotland, hence a *nomen nudum*, but in any case preoccupied (see below).

1819. LEPUS ALBUS, W. E. Leach in Sir John Ross's *Voyage of Discovery*, ed. i., app. ii., pp. xlv-xlvi; ed. ii., vol. ii., app. iv., 15 and 170, the last reprinted in *Ann. of Phil.*, September 1819, xiv., 201, from Brisson; described from Scotland; preoccupied by *Lepus timidus albus*, J. M. Bechstein, *Gemeinnutzige Naturgeschichte Deutschlands*, etc., 1801, i., ed. ii., 1096, described from Thuringia, Germany; Jenyns.

1857. LEPUS VARIABILIS, b. Form der Mittelregion und der Alpen, J. H. Blasius, *Säugethiere Deutschlands*, 424 (part).

1900. LEPUS TIMIDUS TYPICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.* (London), 6th February 1900, 88 (part); Millais.

1906. LEPUS MEDIUS SCOTICUS, Max Hilzheimer, *Zool. Anzeiger*, xxx., 511, 14th August 1906; Trouessart (1910); described from Scotland.

1909. LEPUS VARIABILIS SCOTICUS, M. A. C. Hinton, *Sci. Proc. R. Dublin Soc.*, xii. (N.S.), No. 23, 8th September 1909, 231, etc.

Le Lièvre blanc of the French; *Der Schneehase* of the Germans.

The synonymy (apart from the first two items, which refer to the species *timidus*) is that of the Scottish Hare, without reference to its allies on the Continent; apart from the question of the use of the specific names *timidus* and *variabilis*, which has been already explained above on p. 251, it presents no difficulties. The animal is a fair subspecies, being intermediate in size and colour between those of Skandinavia and the Alps.

It is unfortunate that Leach's name is barred for technical reasons. In 1819 he remarked of a hare obtained during Ross's voyage that it was very distinct from the common White Hare of Scotland (*Lepus albus* of Brisson), and equally so from the *Lepus variabilis* of Pallas. But it is evident that he did not understand the true relationships of these animals; they could not, indeed, be demonstrated until a series of adults from the various European localities was brought together, a work first accomplished by Miller. Hilzheimer, albeit his arrow was shot at a venture, has priority, and the Scottish Hare must be known by the name which he gave it.

Local names:—See under the preceding species. The animal rejoices in a number of names well known in books and too obvious to need explanation, such as Alpine or Mountain, Changing or Varying, Blue, Snow, or White Hare.

History:—"White hares" must always have been well known in the Highlands, and are mentioned as occurring in the Orkneys in the twelfth and again in the sixteenth centuries (see p. 310). Zoologists, however, appear to have been ignorant of their occurrence. They are *not* definitely named in Gordon's *History of the Earldom of Sutherland to* 1630, published in 1813; and have no place in Merrets' list (1666), nor in Ray's *Synopsis*, although the latter naturalist was well acquainted with the existing descriptions of Varro's Varying Hare, which he records as being frequent in the mountains near Padua, and having ears with black tips. Like Topsel (1658), he evidently obtained his information from Gesner, but the latter's assertion (p. 683) that he had heard of White Hares also in England, probably refers to varieties of *L. europæus*, two of which were mentioned by Morton in his *Natural History of Northamptonshire*, 1712, 445. A statement that there is an annual rent, consisting of two white hares, at Sheffield, enjoined by ancient deed, is due to an error in reading 39 Edw. iii., where the correct words are "duos leporarios albos" = "two white greyhounds" (see Pegge's *Anonymiana*, 1818, 159.)

It is probable that the first printed allusion to the Scottish Hare by a British zoologist was that of Gilbert White, who wrote of it to Pennant (letter xxvi., 8th December 1769):—"It pleases me to find that white hares are so frequent on the Scottish mountains, and especially as you inform me that it is a distinct species; for the quadrupeds of Britain are so few, that every new species is a great acquisition."

White's remarks are explained by Pennant's own statement in his *Tour in Scotland* (1772, 96), that on 31st August 1769 he met with "white hares" on the summits of the hills by Loch Ness, Inverness, and (p. 102) that on 4th September following he noted the occurrence of "Alpine Hares" at Glencoe, Argyllshire. The species made its first appearance in his works in 1770 (see above, under Synonymy). He probably also observed these animals on the island of Islay, since in writing of its fauna in 1774 (p. 230) he mentions "hares: the last small, dark-coloured, and bad runners." It is pretty certain that he sent one to Daines Barrington, for the latter, who, like Pennant, corresponded with White, wrote (*Phil. Trans.*, lxii., 1772, 11, footnote *b*) of the "Alpine Hare" that "This species of Hare is found in the Highlands of Scotland, whence I received a specimen, which I had the honour of presenting to the Museum of the Royal Society." The Museum or "Repository" of the Royal Society was handed over to the British Museum in 1779, but its contents were not specially labelled, so that Barrington's specimen cannot be traced.

Another writer, Walker, whose *Essays* (see Synonymy) although not published until 1808, were probably written between 1764 and 1774, must have known of the existence of White Hares at an early date, but there is no means of ascertaining exactly when, and he may have obtained his knowledge from Pennant.

Distribution:—The Scottish Hare is now indigenous only to the **Highlands of Scotland**. Elsewhere in Scotland, although not indigenous, it is widely distributed owing to numerous introductions, the first of which took place in the 'thirties and 'forties (W. Evans), in the counties of Peebles, Ayr, and Lanark. From these districts the hares dispersed widely, and they now frequent all hills of 1500 feet and upwards, and very many of lower elevation. The subspecies may, therefore, be described as thoroughly established in all suitable localities throughout the south and south-west of Scotland (for further particulars, see Alston; Service, *Zoologist*, 1893, 265, and 1895, 375; Boyd Watt, *Trans. Nat. Hist. Soc.* (Glasgow), vii., N.S., February 1905, 13; W. Evans; and Harvie-Brown's Faunas); but in all cases south of the Clyde and Forth, as the result of introduction by man. The latest extension of range, as reported by W. Evans includes the Berwickshire portion of the Lammermuir Hills, where it is fast becoming plentiful.

Where not shot down, the Mountain Hare is extremely numerous in many parts of the Highlands; in so much so that although its pursuit is not valued from a sporting point of view, it is customary to organise "drives" for its destruction. In one such drive at Logiealmond, Perthshire, in November 1899, six guns killed 1289 in one day (Lascelles, *The Hare*, cit. supra, 99; see also Harvie-Brown and Buckley's *Moray Basin*), so that it is not surprising to find that its numbers have been considerably reduced in many places. Under the artificial conditions imposed by man its present distribution is very unstable; it is undergoing extermination in one district, introduction in another; and, it seems, therefore, unnecessary to give a detailed list of localities.

On the whole it appears to be naturally (*i.e.*, apart from the influence of man) an increasing animal, and Scottish naturalists have more than once alluded to a supposed newly acquired habit of descending to the cultivated lands, or to those near the sea. Harvie-Brown and Macpherson (*North-West Highlands and Skye*, 44) connect this propensity with heavy falls of snow on the higher land, and Millais (*Field*, 18th February 1911, 330) with hard winters. The latter states that in 1881, 1885, and 1894, large numbers of Blue Hares descended from the mountains above the Tay in Perthshire, and some remained "in the roughs and woods at river level for two and even three seasons afterwards"; the result was a good deal of hybridism with the Brown Hares. The same habit prevails at all seasons in the Outer Hebrides where heavy snow-falls are rare (Harvie-Brown and Macpherson, *op. cit.*).

Wherever Blue Hares are now found in the **Scottish Islands** their presence is due to introduction; but, although there is little evidence, it is not improbable that they were originally indigenous in the Orkneys, as well as in the Outer and Inner Hebrides. There are published records of their occurrence in Arran (Alston), Mull (imported by Colonel Gardyne of Glenfora), where Irish Hares have also been introduced (Harvie-Brown and Buckley), Islay (Pennant; see under *History*), Skye (Harvie-Brown and Macpherson), and Raasay (Macpherson). In the Outer Hebrides they are absent from Barra, North Uist, and South Uist, are nearly extinct in South Harris, and fairly numerous, although of poor appearance, in Lewis and North Harris (Millais); in North Harris they have long been treated as vermin (Harvie-Brown and Buckley).

They are absent from the Shetlands, but, as stated above, there is evidence that they were formerly indigenous to the **Orkneys.** Barry (316) quotes a passage from the Sagas wherein Earl Harold is said to have gone to Gairsey to hunt hares, in the twelfth century. In a description of the islands written in 1529 by Jo Ben (=John Bellenden, Archdeacon of Moray), occur the words, referring to Hoy:—"albi lepores hic sunt et capiuntur canibus"; and in 1684 Sibbald wrote: "In *Orcadibus* reperitur, crinibus candorem nivalem referentibus." The last note of the indigenous stock appears to have been that in

Mackaile's MS., dating from near the end of the seventeenth century, as quoted by Baikie and Heddle:—"There are no foxes nor hares, only I was informed that about eighty years ago there were several, either white or black hares, on the two great mountains of Choye."

They have been reintroduced to Gairsey (Harvie-Brown and Buckley) and Hoy, but Millais stated that he could obtain no news of them on a recent visit to the islands.

Scottish Hares have been introduced into many **English counties,** where they seem to thrive as well on moors and hillsides as in Scotland. It would be impossible to give a complete list of records, especially as the animals sometimes spread quickly over the country and colonise a wide area. In Cheshire, for instance (Coward and Oldham), they have firmly established themselves on the uplands as the result of an introduction from Perthshire into Yorkshire. In the latter county they have greatly increased, so that in May 1893 a keeper counted fifty within range of his field-glasses (Coward, *Zoologist,* 1901, 73-75); they have also appeared in Derbyshire, but in the north of Stafford the descendants of an introduction effected about 1906 have been exterminated (Masefield, *MS.*). Abel Chapman has kindly sent me a note of a recent introduction in Northumberland, near the Roxburgh border. In **Wales,** too, there have been several introductions, so that White Hares may be seen on many of the mountains, especially in North Carnarvon (Forrest). A notable instance is that of the second Lord Penrhyn on Llandugai Mountain; the late G. W. D. Assheton Smith brought a few hares from these mountains to his park at Vaynol, near Bangor (see also under Irish Hare), but they did not thrive well, for which information I am indebted, through the kindness of Forrest, to L. V. Lort. These hares came from Abercairney, near Crieff, Perth.

There has been at least one **Irish introduction,** viz., on the coursing grounds at Black Brae, Co. Londonderry (see Barrett-Hamilton, *Irish Naturalist,* March 1898, 76).

The numberless transportations by sportsmen of Brown, Scottish, and Irish hares are probably now past accurate tracing in detail. Where reasonable care is taken to transfer individuals in good health, no difficulty whatever is found in naturalising either of the three in another's territory. Frequently an introduction is put down as a failure either because the hares are shot down by strangers before they have become established, or because they are so badly injured in transit that they perish after having been released. They are strong, violent animals, and easily knock themselves about in a box, and should be dispatched in a package so arranged that each has a separate compartment.

Distribution in time:—No fossil remains of hares have been described from Scotland, and all those found in England appear to belong to Hinton's Hare, *L. anglicus*, which has been identified by its describer from Ightham Fissure, Kent; Somerset, and from Longcliffe Cave, Derbyshire.

Status:—The Blue Hare of Scotland differs in some important respects from the Irish Hare, and from its forerunner the extinct Hinton's Hare, and is very closely allied to the subspecies of *L. timidus* inhabiting continental Europe. This fact suggests a comparatively recent connection between Great Britain and the Continent, and leaves it an open question whether the west Skandinavian stock of *L. timidus* migrated there from Scotland or *vice versâ*. If there are really two subspecies in Skandinavia, one of them may have reached that country from the East. The question will be found discussed again under genus MICROTUS.

Description:—Both in external and cranial characters the Blue Hare is typical of the group *Lepus*. It differs from the Brown Hare in its smaller size, larger head, rounder and fuller eyes, and shorter ears, which when bent forward, hardly reach the tip of the nose. The legs are relatively longer; the tail is shorter and wholly white; the fur is soft and woolly; the whiskers are not nearly so long and coarse, and the hair on the soles is softer. The animal is in summer dusky rather than tawny or "ochraceous," and in winter more or less white; when the white and dusky shades are intermingled it exhibits the tint popularly known as "blue."

In the **fur** the annulated hairs, although long and piercing the underfur, are not nearly so strong and conspicuous as in the Brown Hare, and the whole pelage is consequently softer. There are fewer of the extra long dusky hairs.

The **underfur**, which, however, in a healthy animal in good coat does not show through the hairs except on the nape, flanks, and rump, is on the upper side in summer bicoloured, having a dusky base tipped with "seal brown" or even "clove brown"; it passes gradually to white on the under side, as also frequently on the rump.

The ordinary hairs exhibit annulations corresponding to those of *L. europæus*, *i.e.*, they are dusky, with a whitish base and a subterminal band of "seal brown" or "clove brown." Frequently, however, the dark tips are absent, having probably been worn away, and there is much variation in tint, probably in accordance with the age of the hairs. In a healthy adult the general colour of the back is derived from the blended effect of the annulations, so that the upper side affects some shade of "blue," or deep brown, bordering on dusky; sometimes it is grizzled or almost frosted. On the rump the extra long hairs with black tips are more numerous, and contrast with the light underfur, but they are scarcer on the face, which accordingly has a clearer appearance.

The tip of each ear is black for an extreme depth of about 30 mm. externally; internally the black colour appears only as a thick rim, having a width of about 5 mm. Beneath the black tip the exterior half of the posterior surface and the whole of the interior is grey, with the border whitish; the rest of the ear is clothed with brown hairs tipped with black, the general colour being like that of the back. The outer surfaces of the limbs differ only from the back in being lighter in colour, and having fewer black-tipped hairs. The soles are dusky. The belly and tail are white; the chin and upper throat, dirty white; the lower throat and upper breast resemble the back, but are of a less clear tint. The line of demarcation is very uncertain and variable, depending on the season. The soles are soft to the touch.

Leverets have a woolly juvenal coat, as described on p. 162; the subterminal bands of the hairs are lighter, so as to give a frosted appearance. The upper side of the tail often carries a few dark hairs.

In the full **winter coat**,[1] which, owing to a great development of the wool, is closer, fuller, and longer than that of summer, both hair and wool, except on the black ear-tips, are white; but the dorsal region always retains a remnant of pigment, and parts of the backs of the ears and of the face are not infrequently coloured as in summer. The feet are very thickly furred. The white coat begins to appear in September, and is perfected by the middle of November or the beginning of December, the commencement of the process being slow, the completion rapid. Any moult which takes place is so gradual and difficult to observe that it may easily be overlooked, and, as stated above on p. 303, its existence does not preclude direct abstraction of pigment. Sometimes the animal becomes paler all over, but usually the feet, with portions of the ears and of the head, are the first to change; the portions of the head which change first being the muzzle, the bases of the ears, and two lines running thence, one on each side, to the muzzle and including the eyes. The white colour then gradually advances up the legs and flanks, first crossing the upper surface at the neck, and isolating the back and part of the top of the head. Meantime spots of grey or white may precede the general advance. According to Collett, Norwegian hares cast the underfur after the hairs in autumn, but before them in spring, when white hairs may be found overlying pigmented underfur, and this appears at first sight to be true of the Scottish Hare, of which specimens in moult have been sent to me by Rodger; but in these there was present, underlying the long white winter coat, both pigmented hair and wool, most distinctly coming up together, so that I suspect Collett to be in error. The spring moult is much more easily observed, and there has never been doubt about it. Although irregular, it is much less so than that of autumn; some individuals may regain their summer coat in March, while others received on 24th April 1899, through Ogilvie-Grant, from the third Lord Cawdor, Cawdor Estate, Nairn, were then in full moult; and the same date is applicable to Perthshire (Rodger). In the Outer Hebrides also the white coat may be carried until the end of April (Harvie-Brown and Buckley, *Outer Hebrides*, 39), and in the south of Scotland partially white hares may be seen until the third week of that month (Evans for the Ochils), and even later (4th May, Campsie Fells, Clyde area, Boyd Watt; 9th May, Pentlands, one partially white, Evans, *MS.*). In Wales A. H. Macpherson (*Zoologist*, 1890, 216) observed two apparently quite white individuals at a height of 2500 feet on Snowdon, on 6th April 1900. The variation in details is easily accounted for as resulting from an irregular and almost continuous change of coat influenced and subject to local conditions of climate, shelter, food, and the idiosyncrasy of each animal.

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[1] Karl Pearson has figured a skin of this hare for each month in the year, but his descriptions have not yet been published (*Albinism*, 1911, fig. YY*a*). Abnormal skins are also figured (ZZ).

The **skull** is typical of true *Lepus* (see above, p. 293). It differs from that of *L. hibernicus* in its smaller size (see details under *L. hibernicus*, where every item of the latter, except the length of the mandibular tooth-row, is greater); and in the more elevated superciliary processes. The **teeth**, both incisors and molars, upper and lower, are narrower, lighter, and shorter than in *L. hibernicus;* hence the mandible is not so deep, and the growing ends of the lower incisors show just in front of the tooth-rows. In *europæus* the mandible is longer, and, in agreement with the shorter cheek-teeth, shallower; the growing ends of the short lower incisors fail to reach the tooth-rows by at least the lateral breadth of a cheek-tooth (see Fig. 48, p. 315).

Individual colour variation is very frequent and conspicuous, being dependent, besides age, on the amount of whitening undergone by individuals. Apart from the influence of moults and whitening, there appears to be frequently present a certain amount of dichromatism, which exhibits itself in two varieties, one the ordinary deep brown form, the other yellowish.

Abnormal colour variations are rare. A black female in the possession of the Duke of Portland was taken at Braemore, Langwell, Caithness, on 3rd February 1902 (Dunbar, *Ann. Scott. Nat. Hist.*, 1902, 250; Anstey, *Field*, 22nd February 1902, 281). Another black specimen from Achnaclay, Caithness—not Galashiels, Roxburgh, *fide* Eagle Clarke —(Small, *Ann. Scott. Nat. Hist.*, 1903, 116), is now in the Royal Scottish Museum. Buff varieties have been recorded, as by Millais, but the species has not always been made clear; a yellow pink-eyed individual was observed to turn white in winter (Crawshay, *Field*, 31st

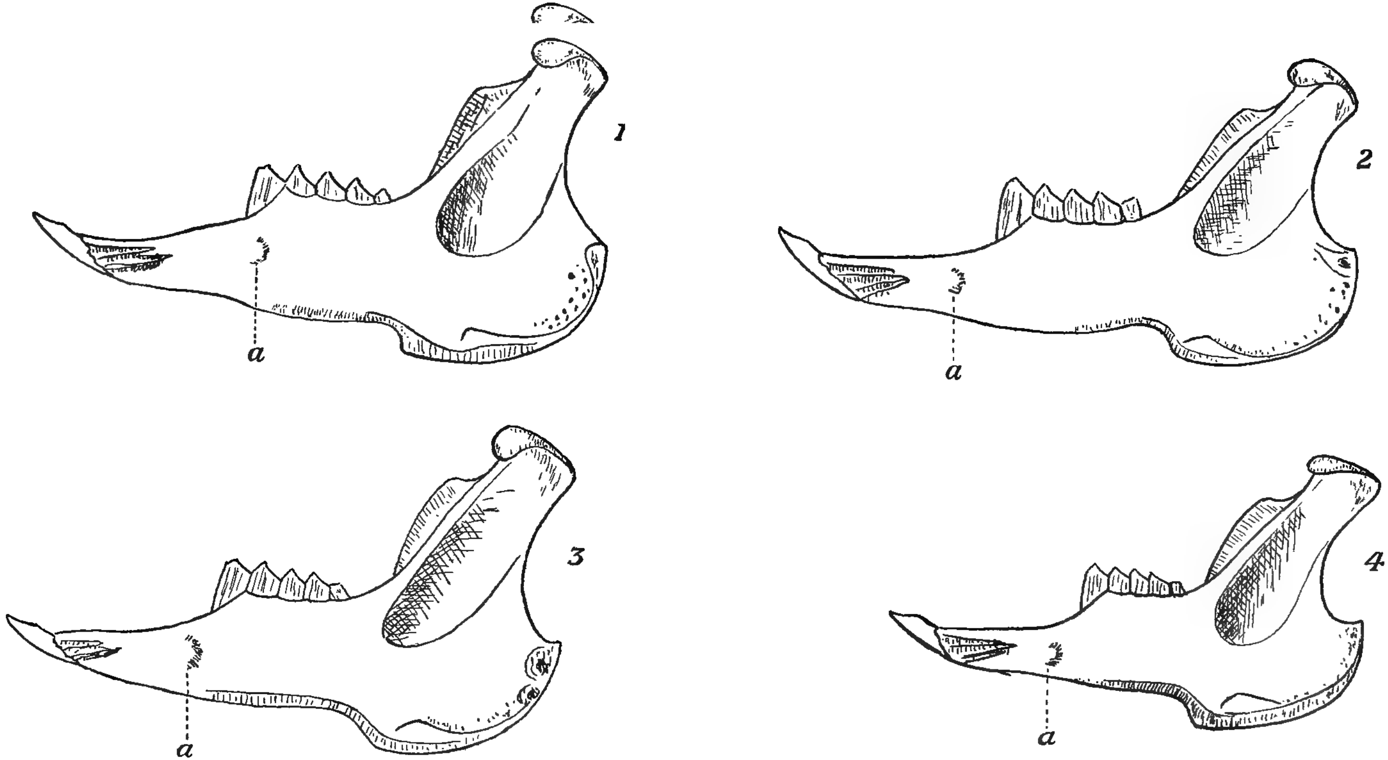

FIG. 48.—RIGHT RAMUS OF MANDIBLE (inner view) OF (1) *Lepus hibernicus*, (2) *L.* (*Eulagos*) *europæus*, (3) *L. timidus scoticus*, (4) *Oryctolagus cuniculus*. (Natural size.)

(*a*) Little lump marking position of the growing end of the incisor. [*Drawn by M. A. C. Hinton.*

For descriptions, see pp. 175, 249, 294, 314, and 333.

October 1891, 655). A cream-coloured example was taken at Torish, Ben Duan, Sutherland (Buckley, *Ann. Scott. Nat. Hist.*, 1892, 158).

Hybridism:—See above under genus LEPUS, p. 236.

Geographical variation:—There are several closely allied subspecies. The true *timidus* of southern Skandinavia, which is mainly a south coast form, ranging west to Jæderen, is the largest, having each hind foot[1] measuring as much as 160, and the occipito-nasal length of the skull as much as 103 mm.; this is the "Plain" or "Jæderen Hare" of the Norwegians, who recognise also, in northern Skandinavia and the mountains of the south, a Common or "Fjeld Hare," to which, if it be distinct, Nilsson's name *collinus* seems to be applicable. The former is characterised, although not universally, by a grey winter coat correlated with a tendency of the black ear-tip to spread downwards, forming a noticeable patch on the outer surface of the ear; in the latter the winter coat is white and the ear-tip restricted. *L. timidus varronis* (Miller) of the Alps is a smaller animal, with the hind feet each about 150 mm. long and the occipito-nasal length of the skull 93; the winter coat is white or whitish, never grey as in the south Skandinavian form; the summer coat is lighter and greyer than in typical *timidus*. *L. timidus scoticus* agrees more nearly in size and appearance with the Alpine than with the Skandinavian forms; but it has shorter ears, is darker in summer, and is not known to become pure white in winter.

The subspecies of *L. timidus* decrease as a rule in size from north to south of the range of the species. This is also the case with the arctic hares of North America, where the northernmost subspecies of *L. arcticus* appear, judging from the published descriptions, to be larger than the southern. In Asia also *L. tschuktschorum* is larger than *L. gichiganus*, and *L. altaicus* is smaller.

Skull (range of nine specimens, eight in collection of the British Museum):—Occipito-nasal length, 83·6 to 89; condylo-basal length, 76 to 81; zygomatic breadth, 43 to 47·4; breadth at inter-orbital constriction, 18 to 22·2; breadth at post-orbital constriction, 15 to 16·2; breadth of brain-case, 30 to 33; nasals (diagonal), 36 to 40·9; greatest breadth of both nasals together, 17·6 to 22·1; length of diastema, 23·2 to 27·7; length of mandible, 66·4 to 70; length of maxillary tooth-row, 16·6 to 18·2; length of mandibular tooth-row, 17·2 to 20.

Weight, in lbs. and oz.:—This is less than in the Brown Hare, and most Scottish naturalists give the average as between 5 and 6.

Harvie-Brown sends me the following:—Argyll—January, 6^{10}, 6^{8}, 5^{12}, 5^{9}, 5^{8}, 5^{8}, 5^{4}, 5, 4^{4}, total nine averaging about 5^{9}; August, 6^{4}, 6, 5^{14}, 5^{12}, 5^{12}, 5^{12}, 5^{2}, 5^{1}, 4^{6}, total nine averaging about 5^{9}; December, 6^{8}, 6, 5^{12}, 5^{8}, 5, 4^{8}, 4^{8}, total seven averaging about 5^{6}; range of twenty-five Argyll specimens (some probably immature), 4^{4} to 6^{10}, average about

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[1] In each case including claws.

DIMENSIONS IN MILLIMETRES:—

	Head and Body.	Tail (to end of vertebræ).	Hind foot, with claws.	Ear.		Weight.*	
				To notch.	To nape.	Lbs.	Oz.
ADULTS IN COLLECTION OF BRITISH MUSEUM OF NATURAL HISTORY.							
MALES:—							
1. Cromlix, Dunblane, Perthshire, Capt. the Hon. A. Hay Drummond, 27th Oct. 1896. (No. 97.2.15.2) . . .	492	60	135	68	..	..	
2. Do., 29th Dec. 1896. (No. 97.2.15.5) .	482	63	139	69	..	..	
3. Do., 24th April 1897. (No. 97.5.13.1) .	457	45	129	68	..	..	
4. Do., 24th April 1897. (No. 97.5.13.2) .	458	46	139	71	..	..	
5. Do., 24th April 1897. (No. 97.5.13.3) .	477	50	138	73	..	..	
6. Cawdor, Nairn, Earl Cawdor, 31st Oct. 1898. (No. 98.11.2.1)	502	52	140	75	..	..	
7. Altyre, Morayshire, Sir Wm. Gordon-Cumming, 24th January 1894. (No. 94.2.15.1)	500	63	130	..	..	..	
8. Do., 2nd Dec. 1893. (No. 93.12.4.2) .	485	57	127	..	..	..	
9. Do. (No. 93.12.4.3)	501	64	135	..	..	..	
10. Dallas Lodge, Forres, Sir W. Gordon-Cumming, 10th November 1900. (No. 3.1.27.1)	465	43	129	71	..	..	
Average of 10 males	481	54	134	70·5 (Av. of	.. 7 only)	..	
FEMALES:—							
1. Cawdor, Nairn, Earl Cawdor, 31st Oct. 1898. (No. 98.11.21.2) . .	510	50	138	77	..	..	
2. Do. (No. 98.11.21.3)	504	68	135	67	..	..	
3. Cromlix, Dunblane, Perthshire, Capt. the Hon. A. Hay Drummond, 7th Dec. 1896. (No. 97.2.15.4) . . .	470	62	132	70	..	..	
4. Dumfriesshire, H S. Gladstone, 22nd Aug. 1907. (No. 7.8.7.1) . . .	520	67	145	78	..	..	
5. Cairn Edward, New Galloway, Colonel Gordon Maitland, 24th Aug. 1895. (No. 95.10.6.1)	519	69	139	76	..		
6. Do., 23rd Aug. 1895. (No. 95.10.6.2) .	535	58	137	73	..		
Average of 6 females	509	61	137	73	..		
Average of 10 males and 6 females .	492	57	135	72	..	..	
SPECIMENS MEASURED BY A. M. RODGER.†							
MALES, weighing 5 lbs. and upwards.							
1. Pitlochry, Perthshire, 30th Jan. 1911 .	509	70	140	70	95	6	8
2. Do. do. do. . .	491	57	140	70	95	5	10
3. Do. do. do. . .	509	63	152	70	95	6	8
4. Do. do. do. . .	483	63	140	70	95	6	0
5. Do. do. do. . .	495	45	146	70	95	6	6
6. Logiealmond, do. do. . .	522	63	155	70	99	7	0
7. Do. do. do. . .	509	63	146	70	95	7	0
8 Do. do. do. . .	502	70	146	70	95	7	0
9. Do. do. do. . .	483	57	152	70	95	6	0
10. Do. do. do. . .	470	63	146	63	90	5	12
11. Do. do. do. . .	495	54	152	63	90	6	2
12. Do. do. do. . .	491	57	152	63	90	6	0
13. Do. do do. . .	483	57	140	67	92	5	10
14. Do. do. do. . .	491	67	155	63	90	6	12
Average of 14 large males . . .	495	60	147	67	93	6	4

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* Weighed when some time dead.

† Measured down centre of back.

DIMENSIONS IN MILLIMETRES:—

	Head and Body.	Tail (to end of vertebræ).	Hind foot, with claws.	Ear.		Weight.*	
				To notch.	To nape.	Lbs.	Oz.
SPECIMENS MEASURED BY A. M. RODGER—*continued.*†							
FEMALES, weighing 5 lbs. and upwards:—							
1. Perthshire, 14th Oct. 1910 . . .	490	70	145	70	100	6	3
2. Do. do.	505	70	152	80	110	6	3
3. Do. do.	535	60	150	70	100	6	0
4. Do. do.	545	50	150	70	100	5	13
5. Do. do.	500	60	145	70	100	5	10
6. Do. do.	510	60	145	70	95	5	3
7. Do. do.	520	65	145	70	90	5	10
8. Do. do.	540	70	145	70	100	6	4
9. Do. do.	540	80	145	70	90	6	0
10. Do. do.	500	60	145	65	90	5	4
11. Do. 28th Oct. 1910 . . .	490	70	145	70	100	6	3
12. Do. do. . . .	505	70	152	80	110	6	3
13. Do. do.	535	60	150	70	100	6	0
14. Do. do.	545	50	150	70	100	5	13
15. Do. do.	500	60	145	70	100	5	10
16. Do. do.	510	60	145	70	95	5	3
17. Do. do.	520	65	145	70	90	5	10
18. Do. do.	540	70	145	70	100	6	4
19. Do. do.	540	80	145	70	90	6	0
20. Do. do.	475	50	130	70	100	5	4
21. Do. do.	500	50	145	70	95	5	0
22. Do. do.	520	60	145	70	97	5	0
23. Do. do.	530	60	150	70	90	6	2
24. Do. do.	480	50	132	65	90	5	0
25. Do. do.	500	60	145	65	90	5	4
Average of 25 heaviest specimens .	515	62	145	70	96	5	11
Average of 14 males and 25 females .	508	61	146	69	95	5	14
26. Perthshire, 14th Oct. 1910 . . .	485	50	140	60	90	4	10
27. Do. do. . . . , .	450	70	130	65	90	4	0
28. Do. do. . . .	490	60	140	70	100	4	12
29. Do. do.	485	60	140	60	90	4	8
30. Do. do.	450	55	140	65	85	3	8
31. Do. 28th Oct. 1910 . . .	450	70	130	65	90	4	0
32. Do. do.	490	60	140	70	100	4	12
33. Do. do.	485	60	140	60	90	4	8
34. Do. do.	450	55	140	65	85	3	8
35. Do. do.	460	50	140	70	90	4	8
36. Do. do.	485	55	135	70	90	4	12
Average of 11 smaller specimens .	470	58	137	65	90	4	5
Proportionate lengths (approx.) of adults, head and body being reduced to 100, and all other dimensions proportionally	100	12	29	14	19	.	

* Weighed when some time dead. † Measured by tape-line along side of body.

5^8; Stirlingshire—August, 7^5, 6^4, 6, 5^{14}, 5^{12}, 5^{12}, 5^2, 5^1, 4^6, total nine averaging 5^{11}; December, 6^8, 6, 5^{12}, 5^8, 5, 4^8, 4^8, total seven averaging 5^6; range of sixteen Stirlingshire specimens 7^5 to 4^6, the whole lot averaging 5^9 Heavier animals are, however, quite frequent amongst adults where food is abundant, the record being apparently 8^8 (Millais, see below). There is much variability, dependent no doubt on the locality, the food supply, the numbers on the ground, and the presence of immature animals which always form a large percentage of the population.

Six killed at random by A. G. Cameron in North Argyll (*Field*, 9th January, 1904, 50) weighed:—two, 16th December 1891, 15; a female, 1st November 1892, 8; one, 17th November 1892, 8^{5}; one, 22nd November 1897, 7^{8}; one, 7^{4}; average 7^{11}. Millais considers that 7 would be a good average weight, and 8 to 8^{4} not unusual; the three largest selected from a lot of two hundred at Dunalastair, Perth, on 30th October 1897, scaled 7^{12}, 8^{3} (female), and 8^{8} (female).

Distinguishing characters:—From *L. europæus* this hare may be distinguished at a glance at all seasons by its shorter ears. From *O. cuniculus*, which has also short ears, its small white tail and greater size, as shown especially in the hind feet, are distinctive; even in quite small leverets the tail is much shorter than a hind foot.

The cranial characters have been already given in such detail as to need no repetition (see above, p. 293-4).

The Scottish Blue Hare closely resembles the Brown in general habits, so that it will be here only necessary to notice the differences. This similarity has, no doubt, led to neglect of the former by naturalists, and, so far as can be ascertained, no comprehensive account of its life-history has yet been written.[1]

All observers agree that in temperament it is a bolder (or, perhaps, more foolish and irresolute), as well as a more inquisitive animal; and in winter, should the snow melt, its whitish dress and lively habits make it very conspicuous. It often sits in full view, back to the wind, sheltered by an overhanging rock, or at the entrance of a hole or cleft amongst boulders or stones.[2] When startled it will run for a few yards, stop and sit upright to gaze wonderingly at the intruder; and then off it bounds again. But it soon halts, looks around for a few moments, and finally "hirples"[3] away at leisure; which procedure suggests that in the past it has been accustomed to look for danger in the air, where it had enemies in the eagles, rather than on the ground.

In speed and agility it is rated inferior to the Brown Hare, and on its native moors can be run down by a smart collie dog; but this is probably a question of food and condition, since in leg-dimensions it is proportionately superior.

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[1] See, however, "Fur and Feather Series," *The Hare*, by several authors, 1896. J. G. Millais's account of it is also to be praised. There are some notes on habits in Charles St John's *Tour in Sutherlandshire*, ed. ii., 1884, i., 111. Robert Collett's exhaustive description of the very similar Skandinavian Hare is in Norwegian.

[2] Millais, iii., 34; T. A. Coward, *Zoologist*, 1901, 74.

[3] George Sim, 70.

The white winter pelage has been generally belauded as a remarkable instance of protective coloration, and, whatever may have been its origin, it may reasonably serve such a purpose in times or regions of heavy snowfalls. But elsewhere the effect is the reverse of protective, and Mr Coward has rightly pointed out[1] that this hare belongs to a class of animals which may for one reason or another find themselves in an environment to which their colour is quite unsuited.

Referring to the pigmented coat of the Brown Hare, Charles Darwin wrote[2] that "the hare on her form is a familiar instance of concealment through colour." Its value, however, may have been overestimated. The summer coats of the Leporidæ are not by any means alike, being grey in the Rabbit, ochraceous or rufus in the Brown Hare, "blue" or smoky brown in the Scottish, and tawny or foxy in the Irish Hare. In each, however, the chest, under side, and conspicuous ventral surface of the upturned tail are white. In each the new coats are darkest, becoming brighter and clearer as the dusky hair-tips wear away; the winter coats are greyer or whiter, and the pigmented areas are more or less reduced.

In no case are the animals protectively coloured for life amidst the green surroundings of the average modern British summer scenery; but their comparatively small size is in itself a factor of immense value for purposes of concealment, and the abundance of summer vegetation[3] probably renders a coat of assimilative tints unnecessary.

In bare places, stubbles, or ploughed fields, amongst dead leaves, decaying herbage, lichens, or peat, concealment is more effectively secured; on the other hand, the Rabbit's pelage harmonises best with a background of sand.

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[1] *Zoologist*, 1901, 75; see also G. A. K. Marshall on "Conscious Protective Resemblance," *Journ. cit.*, 1900, 536-549; E. B. Poulton, *Journ. et ann. cit.*, 550-554.

[2] *The Descent of Man*, ed. ii., 1889, 542.

[3] A very important point, as anyone will appreciate who tries to course hares in grass of even moderate growth, in which even the keen-eyed greyhounds easily lose sight of their quarry.

Physiological necessities, chemical and climatic,[1] rather than the need of being inconspicuous, appear to have been the factors responsible for the evolution of these divergent pelages. Indeed it looks as if any shade of grey or brown must be equally valuable or valueless for protective purposes in summer. In the short, dark, winter days of the north the importance of any particular shade of colour is problematical, and in any case the white tints would be more advantageous against winged enemies hunting by sight in daylight, than against carnivorous mammals scenting their prey by night.

During the transition from summer to winter pelage, conspicuous white patches appear, apparently recapitulating a stage through which the animals passed in the course of their original attainment of the white winter coat. A protective whiteness would surely have been evolved by a general and uniform lightening of the entire pelage; and it looks as if any protective value which the change may possess is purely incidental.

The summer pelage is advertising, not protective, directly the animal moves, for then the quite brilliant white under side contrasts sharply with the pigmented upper surface. Even when viewed from behind, the white under parts being then invisible, the glistening upturned tail,[2] and, in the varying hares, the lighter bases of the ears, attract the eye. The suggestion is that the animals are coloured to be conspicuous in motion rather than for invisibility when at rest.

I cannot find that Mr Abbott H. Thayer's[3] theory of obliteration through countershading is true for hares or for the Rabbit. The white chest, belly, and tail are particularly conspicuous whenever these parts can be seen, which is practically at all times when the animals are not squatting. But they habitually squat when danger threatens,[4] especially when they are in their forms, thus completely concealing the white parts of their bodies. So far from the white under side being obliterative, it is, if anything, an advertising factor, and shows up the animal from afar, as when one sits up on its haunches to "wash" its face.

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[1] See *Proc. Roy. Irish Acad.*, xxiv., B, 303-314, 1903; also F. C. Selous's views in *African Nature Notes and Reminiscences*, 1908, xiv., 11 and 41. These ideas are further elaborated in the article on the "Common Stoat."

[2] In the Rabbit the tail is also conspicuous when viewed from the front of the animal, as when it approaches *up* a hill. Viewed from behind, the black of the upper side sometimes shows up around the white under surface as a dark margin.

[3] *Op. cit. supra.*, p. 223.

[4] When in their forms they constantly jerk their heads up and down, and thus observe anything unusual while at some distance; they squat on the near approach of a possible enemy.

The tameness of the Blue Hare, especially in the sexual season, renders it a constant source of annoyance to grouse-shooters by tempting their dogs to leave their legitimate business; in deer-forests it also meets with disfavour, as it alarms the deer, but here its numbers are thinned by eagles, foxes, and other carnivorous creatures,[1] which, by the modern policy of the sportsman, are encouraged on these preserves.

Unlike the Brown Hare this species will occasionally go to ground, and habitually hides in clefts of rocks or amongst large stones;[2] without, however, constructing permanent burrows or associating in warrens like the Rabbit. But that it may occasionally excavate temporary retreats for itself, was shown by Mr William Evans,[3] who, in the hills of South Inverness-shire, inspected several short holes varying from two to five feet in length and some six or seven inches in diameter. These were stated to be the work of Blue Hares, and in one case at least there was enough fur adhering to the sides to prove the truth of the assertion; they were supposed to have been constructed in the first instance for the reception of the young; to the adults they could only be a temporary shelter, perhaps a sufficient protection against attacks by birds of prey, but of little value against carnivorous mammals. In the Moorfoot Hills also, where rocks are absent, Mr Evans is informed that the hares often burrow into the exposed faces of peat.

As winter approaches in cold districts the Blue Hare often leaves its summer haunts and descends in search of a more genial climate. In the same way, it resorts to the sheltered sides of the mountains in severe weather, but generally makes for the hill-tops when disturbed. Such seasonal wanderings are purely local, and quite insignificant in comparison with the extensive migrations of hares which are reported to take place, for instance, in Siberia;[1] but, as stated above (p. 237), these movements are accentuated in exceptionally rigorous winters.

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[1] A point of great interest, the inter-relations of rodents and carnivores, as exemplified particularly in North America by the Snowshoe Rabbit and the Lynx, which depends on it for food, is discussed by Ernest Thompson Seton in *The Arctic Prairies*, 1912, 95, etc.

[2] A habit retained by the naturalised Blue Hares in England; see Coward, *Zoologist*, 1901, 75.

[3] *Ann. Scott. Nat. Hist.*, 1892, 267. He has also seen a similar burrow in a peaty bank in central Perthshire (*MS.*).

Its ordinary food is similar to that of the Brown Hare, but its stronger teeth must influence its diet by enabling it to utilise heather or other coarser forage. It is said also to feed in winter on lichens[2] and to chew up the cones of conifers to get at the seeds. Probably also, like the Skandinavian Hare, as described by Professor Collett, it may eat berries in autumn. Its stout fore legs enable it to remove snow from over its food.

Little has been published in connection with the sexual habits, period of gestation, and number of young. They are supposed to be similar to those of the Brown Hare, except that the Mountain Hare is erroneously[3] believed not to produce more than two broods in the year.

There is probably much variation in this respect, due to climate, food, and season; Mr Millais shot females in full milk in September, and has seen many small leverets in that month. He thinks that these are the young of leverets of the previous year; but the facts point equally well to the occurrence of a third litter in the season. Professor Collett states of Skandinavian hares that the sexual season seems to be of variable duration. There many females produce young two or three times in the year, and some pregnant does may be found in every month. The number of young is also variable, but may be as many as eight.[4]

As early as February the female takes up a fixed place of residence, and awaits the male, who finds her by scenting her along the spoor; when hunted, therefore, at that season the female makes very short rounds, while the males may strike out widely.

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[1] John Bell (*Travels from St Petersburg in Russia to Diverse Parts of Asia*, 1763, i., 222, 224, and 231), early in March 1720, met with "prodigious" flocks of White Hares on migration near the river Yenisei and its tributary the Tongusta.

[2] John H. Dixon's *Gairloch in North-west Ross-shire*, 1886, 239.

[3] Having regard to the habits of the Skandinavian Hare (Collett). As stated above (p. 168), the rule would seem to be, the farther north the fewer the litters and the larger the number of young in each.

[4] The American "Snowshoe Rabbit," *Lepus americanus*, may have as many as ten (Thompson Seton, i., 631); and for the Greenland Hare, see above, p. 160.

As a rule during the rutting season, the male spends nearly the whole day wandering about, and pairs, as it is assumed, with several females, usually at night. Frequently rival bucks fight with each other for their mates, so that flecks of wool lie scattered about, and the snow is blood-spotted; in combat they use their incisor teeth and the sharp claws of the fore feet. The does often pair again while they are still suckling young, and superfœtation has been occasionally observed. The pairing shriek is a "hu-hu-hu," which can be heard from afar, but when suddenly aroused a hare may utter a hissing sound.[1]

The Dogrib Indians entice the Hudson Bay Varying Hare[2] by uttering a rasping squeak through the closed lips. Adults of both sexes are attracted, but only during the summer or breeding season; the young seldom respond, and adults rarely a second time; but they may generally be made to return within a certain distance, apparently to get a second look at the intruder, and may then be heard scurrying about and loudly thumping their feet. Sometimes the approaching hare makes a grunting noise.

The flesh of the Blue Hare is usually considered inferior and unpalatable, but its quality is probably dependent on the food, since, like that of the Irish Hare, it is often excellent eating. For comparison it may be noted that the flesh of the Hudson Bay Varying Hare,[3] although at all times innutritious, is very agreeable in summer; it is bitter in winter, at which season the animal feeds largely on the foliage and bark of resinous trees. Indians living mainly on those hares (at whatever season) describe themselves as starving, and are said to grow very thin if no other diet be obtainable.

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[1] In default of British observations, the facts in the two preceding paragraphs are condensed from Collett.

[2] *Lepus americanus*, Erxleben—see E. A. Preble, *North Amer. Fauna*, No. 27, 1908, 200.

[3] Preble, *op. cit.*, 201.

THE IRISH HARE.

LEPUS HIBERNICUS, Anon. in Partington.
LEPUS HIBERNICUS, Bell.

1832. LEPUS TIMIDUS, John V. Stewart, "A List of, and Remarks on, some of the Mammalious Animals, and the Birds, met with in the Three Years preceding 4th December 1828, on the North Coast of Donegal," *Loudon's Mag. Nat. Hist.*, v., 1832, 579; Lydekker, *Handbook to the British Mammalia*, 1895, 225; Barrett-Hamilton, *Irish Naturalist*, 1895, 90; Thomas, *Zoologist*, 1898, 101; Aflalo; Johnston; Scharff, *Trans. Roy. Irish Acad.*, xxxii., B, iv., 199, September 1903, and xxxiii., B, i., 37, February 1906.

1833. IRISH HARE, William Yarrell, *Proc. Zool. Soc.* (London), 88; no definite locality or technical name given.

1835. LEPUS TIMIDUS var. β, IRISH HARE, Leonard Jenyns, *Manual of British Vertebrate Animals*, 35.

1836. "THE IRISH HARE, L[EPUS] HIBERNICUS," Charles F. Partington's *The Brit. Cyclop. Nat. Hist.*, ed. i., ii., 705; ed. ii., ii., 705, 1842; described from Ireland.

1837. LEPUS HIBERNICUS, Thomas Bell, *History of British Quadrupeds*, ed. i., 341; described from Ireland; MacGillivray; Thompson, *Trans. Roy. Irish Acad.*, xviii. (sci.), 260, 28th May 1838, 1839, and *Nat. Hist. Ireland*, iv., 19, 1856; Wood, *Illustrated Nat. Hist.*, "Mammalia," 1861, 584; Sanford, *Quart. Journ. Geol. Soc.* (London), xxvi., 1870, 127; Boulger, *Proc. West London Sci. Assoc.*, 26th October 1875, 29; Leith Adams, *Proc. Roy. Irish Acad.*, ser. 2, iii. (sci.), 99, 1883; Miller.

1837. LEPUS TIMIDUS var. HIBERNICUS, John Templeton, "Irish Vertebrate Animals: selected from the Papers of the late John Templeton, Esq., Cranmore. By Robert Templeton, Esq.," *Charlesworth's Mag. Nat. Hist.*, i., N.S., 404; named only, without description.

1840. LEPUS VARIABILIS, A. Graf Keyserling and J. H. Blasius, *Die Wirbelthiere Europa's*, i., vi. and 30 (part); Harvey, *Fauna and Flora of the County of Cork*, "Mammalia," 1845, 3; Clermont; Bell (ed. ii.); Leith Adams, *Sci. Proc. R. Dublin Soc.*, N.S., ii., 45, 84, 18th March 1878, and *Proc. Roy. Irish Acad.*, ser. ii., iii. (sci.), 99, 1883; Ball, *Sci. Trans. R. Dublin Soc.*, N.S., iii., 334, 18th May 1885; Flower and Lydekker; Lydekker, *Catalogue of Fossil Mammals, . . . in the Science and Art Museum* (Dublin), 1891, 15.

1857. LEPUS VARIABILIS, a *Form der wärmeren Klimate*, J. H. Blasius, *Säugethiere Deutschlands*, 420 and 424 (part).

1891. LEPUS VARIABILIS HIBERNICUS, G. E. H. Barrett-Hamilton, *Irish Sportsman*, 22nd August, 428; Hinton, *Sci. Proc. R. Dublin Soc.*, xii. (N.S.), No. 23, 8th September 1909, 257.

1900. LEPUS TIMIDUS HIBERNICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.* (London), 6th February, 89; Millais; Hilzheimer, *Zool. Anzeiger*, xxx., 511, 14th August 1906; Trouessart.

1900. LEPUS TIMIDUS LUTESCENS, G. E. H. Barrett-Hamilton, *Proc. cit.*, 89, described from a yellowish variety from Donabate, Co. Dublin; Trouessart.

Synonomy:—There is here no trouble The name *lutescens* was applied by me to a yellow variety, which, however, although of considerable interest, is not properly established geographically (see below, p. 334).

Terminology and local names:—See under *Lepus europæus* (p. 251).

History:—Hares must have been abundant in Ireland from prehistoric times. They take their place with other animals in the old hunting legends, and are mentioned in the tract "De mirabilibus Sacræ Scripturæ," believed to have been written about A.D. 650, by the Irish ecclesiastic Augustin (*Proc. Roy. Irish Acad.*, vii., 1862, 518):—"Quis enim, verbi gratia, lupos, cervos, et sylvaticos porcos, et vulpes, taxones, et lepusculos, et sesquivolos in Hiberniam deveheret?" ("Who, for instance, would bring wolves, deer, and wood pigs, and foxes, badgers, and little hares, and 'sesquivoli' [for the meaning of which, see under *Squirrel*] to Ireland?" The use of the diminutive *lepusculos* instead of the ordinary *lepores* is curious, and it might at first sight be thought that this word had reference to rabbits. The meaning is, however, explained by a passage in Giraldus Cambrensis (*Topographia Hibernica*, cap. xxiv., A.D. 1183-1186), who wrote "Sunt et lepores multi, sed minuti; cuniculis quidem tam sui modicitati, quam delicata pilositate consimiles," *i.e.*, "There are also hares, many but small; closely resembling rabbits indeed as much in their habits as in their soft fur." Giraldus thus supplies the first written description of the Irish Hare; it is accompanied by the information that these hares had, like foxes, the remarkable habit of keeping to the woods and coverts when hunted, instead of taking to the open.

An early reference to the animal occurs in Hoveden's *Chronica* (t. ii., 29, Rolls series), wherein it is related that when King Henry II. landed at Crook, near Waterford, for the conquest of Ireland on 17th October 1171, a white hare sprang out of some bushes, and, being immediately captured, was presented to the monarch as an omen of victory. This would be an exceptionally early date on which to meet an Irish Hare in complete winter coat, so that the animal may have been an albino.

In a list of Irish exports of about 1430, the skins of the "Irish Hare" appear, with those of other animals. (See above, p. 189, and also under Squirrel.)

Fynes Morrison, who lived in 1559-1603, described the Irish greyhounds as being so high that they overbear the hares, which were in "great plenty," when they have turned them (Falkiner's *Illustrations of Irish History and Topography*, 1904, 223 and 324).

In the *Ancient and Present State of the County and City of Waterford*, ed. i., 343, footnote, 1746, Charles Smith remarked that "it is no unusual thing even in this county to meet with white hares"; and there are many later references.

The attention of English zoologists appears to have been first drawn to the Irish Hare by the then Lord Stanley, afterwards Earl of Derby, President of the Linnean Society. He exhibited a specimen at a meeting held 5th March 1833 (*Trans. Linn. Soc.*, London, 17, 555), and also provided Yarrell with specimens, whereby the latter naturalist introduced the species to the Zoological Society of London on the following 23rd July (*Proc. Zool. Soc.*, 1883, 88). William Thompson, being present at the meeting of the Linnean Society, stated that, although not hitherto published, the differences between the hares of the two countries were already well known in Ireland; but that Irish naturalists regarded the hare of Ireland only as a very distinct and well-marked variety of *Lepus timidus* (*i.e.* of *L. europæus*).

In 1835, Jenyns, in introducing the Irish Hare as a variety of *Lepus timidus* (which name he applied to *L. europæus*), remarked that it "might almost deserve to be considered as a distinct species." It was not, however, until 1836 that the animal received its specific name (*hibernicus*) in an unsigned article in Partington's *British Cyclopædia of Natural History*. This article antedates the first edition of Bell's *British Quadrupeds*, the description in which is usually cited as the authority for the species; possibly Bell wrote both. The species was accepted by E. T. Bennet in his edition of White's *Selborne*, 1837, 128 (without a technical name), and by MacGillivray, who, in 1838, published an excellent description of the animal taken from nature.

In 1839, Thompson, "on a very minute examination of Scotch and Irish specimens," published his agreement with Bell's conclusion (*Trans. Roy. Irish Acad.*, xviii., 260-271, 18th May 1838, reprinted in *Nat. Hist. Ireland*, iv., 19-26, 1856). Thompson's paper, although he ignores cranial characters, was for its date carefully drawn up, and it might have been expected that his opinion would command attention, formed as it was on the spot, and based on personal knowledge of all the British hares. In 1840, however, Keyserling and Blasius dismissed the species as not different when in summer pelage from *L. variabilis*, although not whitening in winter.

Thompson, perhaps influenced by Blasius, seems afterwards to have changed his position (see Harvey's *Fauna and Flora of Cork*). In 1857, Blasius submitted that the Irish Hare might be a "Form der wärmeren Klimate," but he united it with the quite different hare of southern Skandinavia. This lead had an unfortunate effect, and the animal was subsequently regarded pretty generally by authors either as a "climatic race," or its identity with *L. timidus* was taken for granted. It was thus treated by Alston and Tomes, by Friedel (*Zool. Garten.*, xx., 311, 1879), and, more recently, by Lydekker and by Johnston. It appeared as a species in Wood's *Natural History* in 1861, and in a note in the *Field* of 11th July 1874, 31, T. E. Davies remarked on its size, colour, and fineness and length of leg. In 1891 I suggested that it might eventually be regarded as a subspecies, but I had arrived at no more definite conclusion in 1895 (*Irish Naturalist*, 90), nor had Thomas in 1898.

In 1900 I definitely assigned it to subspecific rank. The subspecific rather than the full specific rank was considered appropriate because it was thought possible, although there was no evidence of it, that there might be overlapping of characters with the Scottish Hare. Moreover, my work dealt with the varying hares of the old world as a whole, so that it was convenient to regard them all as subspecies; lastly, the trend of opinion of naturalists at that date was such that the announcement of a full species from Ireland would have been accepted with incredulity. In proof of this, the works of some recent writers, such as Johnston and Aflalo, are written as if such a species as the Irish Hare had never been mentioned, while Millais, although accepting it, does so only in an apologetic manner and with a hint that the "Irish Hare has slender claims to subspecific rank" (iii., 39). This too, although he prints shortly afterwards Harvie-Brown's statement (*Fauna of Argyll and Inner Hebrides*, 1892, 44), that in the island of Mull the Irish and Scottish Hares "appear to co-exist, and *are recognised, by inhabitants at least, as very distinct varieties, if not species.*" Even writers on Irish Natural History, such as Scharff, treated the animal with a want of sympathy which, in politics, would have been styled unpatriotic.

Status:—In the present work the Irish Hare is given full specific rank because it is a completely isolated form of considerable antiquity, which owes its survival to preservation from competition in an insular area; it is absolutely distinguishable at a glance from its nearer relatives, with which it cannot naturally intermingle and never intergrades or overlaps in characters. When transported to localities inhabited by other hares, as the island of Mull, and Vaynol Park, North Wales, it retains its distinctness. It appears to have directly descended from the late pleistocene *L. anglicus;* the relationship implies a geologically recent connection between England and Ireland.

Distribution:—This hare is restricted to Ireland, where it is found naturally all over the country, both in the mountains and in the plains. Its numbers depend on the amount of persecution to which it is subjected; it has been exterminated in many districts, but, owing to the popularity of coursing, is increasing in others.

It is not known to be indigenous to the smaller coastal islands, though included by Drummond in a list of Rathlin Island mammals compiled in 1835. It has been recently introduced on Clare Island.

It has been introduced into various localities in England, Wales, and Scotland, and large numbers are said to be exported annually for coursing from one estate in Co. Down (Warrand, *Zoologist*, 1895, 104). The High Gosforth Park Coursing Club, Newcastle-on-Tyne, imported the following live hares, mostly from the Wicklow mountains:—In 1886, 262; 1887, 193; 1888, 199; 1889, 342 (E. Britten, secretary; see also below, p. 339). In Islay some were turned down previously to 1818 (Thompson). In Mull there is a colony emanating from twelve hares sent from Wicklow about 1860 (Notman, *Field*, 10th January 1903, 53); here Irish and Scottish Hares may be seen together and keep their specific characters, the Irish retaining their reddish pelage, greater weight, and turning white in winter less readily than the Scottish Hares; they also exhibit a tendency to the familiar buff variety, which I named *lutescens* in 1900 (see below, p. 334; also, Barrett-Hamilton, *Irish Naturalist*, 1898, 75).

A well-known introduction is that of the late G. W. D. Assheton Smith at Vaynol Park, Bangor, North Wales, which L. V. Lort thinks took place about 1881; new blood was added in the shape of thirteen bucks and eleven does from Caledon estate, Co. Tyrone, on 27th January 1899 (Lort per Forrest). A specimen from Vaynol in the British Museum is partly of the usual reddish colour, having changed three parts white. All three British hares are, or were, found in or round Vaynol Park, but Lort reports that the Irish are now nearly extinct.

There must have been many other introductions; *e.g.* in Yorkshire (see below, p. 340). An Irish Hare is said to have been shot at Barnstaple, Devon, on 1st January 1902 (Tegetmeier, *Field*, 18th January 1902, 73).

Distribution in time:—Numerous remains of hares were found in the Shandon (Brennan, Carte, Leith Adams) and Ballinamintra caves, Co. Waterford (Leith Adams); in all the strata of the Coffey and Plunkett caves, Co. Sligo (Scharff, *Trans. Roy. Irish Acad.*, xxxii., 1903, B, iv., 199); in the Catacombs, Alice and Gwendoline, Newhall and Barntick caves, Co. Clare (Scharff, *Trans. cit.*, xxxiii., 1906, B, i., 37-38). Although not all of pleistocene age, many of the remains are undeniably ancient and contemporaneous with those of mammoth, reindeer, gigantic Irish deer, common and banded lemmings, arctic fox, spotted hyæna, bear, and probably of other animals, in a fauna of late pleistocene age corresponding with that illustrated by Ightham fissures, Kent. They have long been recognised as too large for *L. europæus*, and have therefore been referred to *L. hibernicus* (as by Leith Adams, *Trans. cit.*, xxvi. (sci.), 1879, 211). Femora from the Sligo caves measure 125 and 130 mm. and a tibia 145 mm. in length; femora from Newhall and Barntick, Co. Clare, vary between 117 and 131 mm., tibiæ between 129 and 149·5 mm., which dimensions agree fairly well with those of modern specimens of *L. hibernicus*.[1]

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[1] The literature of the older caves is so extensive that it is impossible to give more detailed references.

Description:—The Irish Hare differs from the Scottish in its larger size, generally russet colour, not smoky brown or "blue," and in its irregular assumption of a white winter coat. It has longer ears and skeleton of the tail (although the actual fur of the Scottish Hare may be longer); flatter inter-orbital region; less highly elevated superciliary processes; longer, broader, and heavier incisors; and longer and stouter molars.

The arrangement and annulation of the **fur** and the general colour pattern of the body, tail, and ears are the same as in the Scottish Hare, but the dark browns of that species are represented by richer tints near "tawny," "tawny ochraceous," or "ochraceous." Owing to the fact that a white hiemal coat is only partially assumed, the ochraceous hues may become exaggerated, both in old and young, as the hairs of the winter coat grow old and their black tips wear away, so that they often appear as "red as a fox." In fresh pelage, on the other hand, the black tips are more prominent and the general colour is deeper and darker. In the pigmented coat the line of demarcation is comparatively definite. The whiskers may be black or white. The soles are brownish.

Leverets at birth are about the size of rabbits at the twelfth or fourteenth day, and probably weigh about 2 oz.; they have very short, broad, almost triangular ears, eyes less prominent than in adults, head markedly round, and underfur much more abundant than hairs. For the first few days they resemble rabbits, but have larger ears and feet, shorter tails, and lighter coloration; they are also more woolly, especially in early spring, when the coat is very thick. Their colours are variable even in the same litter, but are quite different from those of adults. In the first coat the underfur is about equally bicoloured, the bases being dusky, the distal ends of a tint similar to the subterminal bands of the long hairs; the latter are much lighter and less rich than in adults, being lighter than "isabella colour" or "clay colour," or approaching "buff"; in some specimens the tints resemble those of *L. europæus.* As the animal grows the light tips become longer at the expense of the dusky bases. The rump, tail, and ears present the same pattern as in adults, but the amount of grey on the latter varies or may be nearly absent. The tail is darker than in adults, and may be heavily sprinkled with black hairs on both sides; it whitens gradually. As the animal advances to maturity its tints become richer, commencing with the upper side of the head, but quite large animals are still in an intermediate condition, evidently representing a post-juvenal coat. Leverets with the hind foot measuring 100 to 105 mm. (including claws) were found to be in the lightest stage; one with the hind foot 118 mm. was intermediate; one killed in January with the hind foot 134 mm. had not acquired a fully adult appearance, neither had a male, weighing 6 lbs. and with the hind foot 137 mm., killed early in September 1910, nor yet another weighing 7 lbs. in November of the same year; in all these the skull was found to be immature.

In winter the animal is to a variable, but, as a rule minor, extent white. The rump, flanks, legs, and backs of the ears are most frequently whitened, the face is often affected and the eyes ringed. Rarely (yet sometimes even so far south as Wexford or Waterford) the whole upper surface becomes almost white, leaving only portions of the head brown. Usually "islands" of brown colour remain on the back, and the constantly present sprinkling of reddish hairs serves to distinguish the Irish from the Scottish Hare.

The feet (see Plates xix. and xx.) are not so thickly furred as in *L. t. scoticus.*

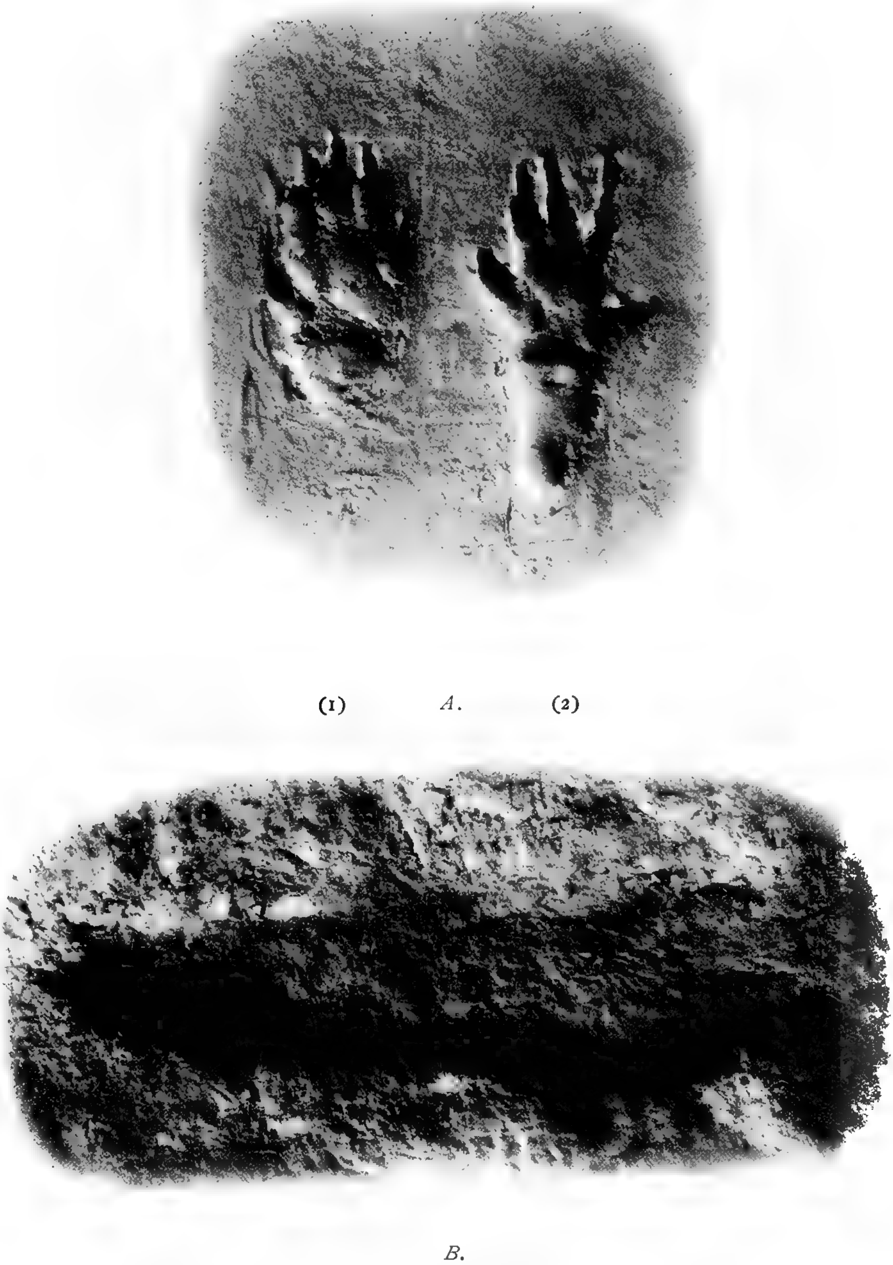
Winter whitening:—In 1746 white hares were mentioned by Charles Smith (*op. cit. supra*, p. 326); and, since the time of William Thompson, the fact has been well known that the Irish Hare may and often does undergo a considerable change in winter. This takes place to some extent every year as well as all over the country, but frequently escapes notice except in its more conspicuous stages. In spite of this, the statement has often been made until quite recently that the Irish Hare does not turn white in winter.

Thompson gave instances of whitening occurring in hares from the north-east to the south-west of Ireland. The whitest he had ever seen was sent to the Belfast Museum from Glenarm Castle, Co. Antrim, in January 1845. It was "even whiter than a winter Alpine one obtained in the same season." In a note sent to Robert Patterson by Lord Antrim from the same locality, it is stated that in the cold, snowy winter of 1878-79 large numbers of hares of all ages turned "completely" white, both on the hills and the low grounds, and remained so until the end of April. Thompson also mentions a "white hare" seen in Massareene deer park in the same county in December 1847; this individual had been white in the previous winter. That these were not isolated instances is shown by a report received by Thompson from Tollymore Park, Co. Down, on 8th March 1845, that there were "a great number of white hares on the mountain; some of them snow-white"; and in February 1842 Thompson had himself inspected several partially white hares from Shane's Castle Park in Co. Antrim. F. J. Montgomery also wrote (*Field*, 16th March 1907, 445), that hares very often turn white in Co. Antrim, particularly on the mountains and in severe winters. From the south of Ireland Thompson had reports of two killed in an advanced stage of whitening, near Clonmel, between Cos. Tipperary and Waterford, and near Mitchellstown on the Tipperary border of Co. Cork. He had also a record of the occurrence of winter whitening, although irregularly, in Co. Kerry.

Thompson was corroborated by T. E. Davies, who wrote (*Field*, 11th July 1874, 31), from Buncrana, Co. Donegal, that in Cos. Derry and Donegal the hares often turn white, except a few hairs on the head and tips of the ears; by Edward Ker, who spoke for the Mourne Mountains, Co. Down (*Journ. cit.*, 18th July 1874, 81); and by Lord Clermont. The latter reported (*Zoologist*, 1882, 107) a very decided annual change of colour from the summer to the winter garb in the hares at Ravensdale Park, on the borders of Cos. Armagh and Louth, and that the white prevailed more in hard than in mild winters. Warrand also pointed out (*Journ. cit.*, 1895, 104) that at Finnebrogue, near Downpatrick, Co. Down, while nearly all assume a much lighter shade of fur when the cold weather sets in, a considerable number turn very white; but Maxwell, the owner of the property, informs me that extreme stages of whitening are rarely reached. To these records may be added Cos. Galway, Wicklow, Wexford, Waterford, and Monaghan, the latter on the authority of my correspondent James Brodie. In Wexford some individuals turn remarkably white almost every year even at sea-level on the rich pastures of Kilmanock. From Kilmacthomas, Co. Waterford (see also Smith, quoted above on p. 331), I have seen one of the whitest Irish Hares known to me; one from Co. Wicklow, and another (a very white doe) from Ballybrophy, Queen's Co., are in the Dublin Museum. From Galway there are many records; for instance, Whyte reported that of five hundred and eighty-two hares killed in two days, ten were white or nearly so (*Field*, 12th February 1876, 158); he thought the animals turned whiter on grass than on heather (*Journ. cit.*, 25th July 1874, 87); in the Kylemore townland the late G. H. Kinahan (*Land and Water*) shot during one winter at least twenty piebald hares, some nearly white; and one "perfectly white" was seen near the top of Derryclare, one of the Twelve Pins (Caton Haigh, *Zoologist*, 1895, 185-186). Others in similar condition have been observed near Bruff, Co. Limerick. Lastly, Harting (*Zoologist*, 1895, 104 and 149; also *Field*, 29th August 1891, 331-332) has examined a number of Irish Hares in all stages from brown to white.

As stated above, winter whitening in the Irish Hare is very irregular in its action. It is evident that few individuals whiten by habit, and that the amount of stimulus required to cause whitening is in each case very variable. Thus, on a given area occupied by a number of hares a few will turn very white, a number conspicuously although only partially white, while others will have only whitened a little. Apart from individual constitutions, the degree may depend on the locality or ground, since Whyte (*op. cit. supra*) wrote that in his district all the white hares were killed on the lower ranges of green limestone, and he never remembered to have seen a white one on the heathery hills. In Connemara Kinahan found the hares whitening more

PLATE XXI.



Tracks of, *A*, Hedgehog, (1) left fore, and (2) left hind, foot (artificial imprint, life size); *B*, Irish Hare (left hind foot, natural imprint, reduced in size), Kilmanock, 1910, showing the whole length of foot placed on the ground.

or less on the Banneobela range, but not in some other parts. Again, the hares in some enclosed parks are believed to be particularly subject to whitening, which in such cases has been attributed to deterioration caused by inbreeding (thus Pomeroy in Harvie-Brown and Buckley's *Fauna of Argyll and Inner Hebrides*, 1892, 43, footnote).

The white may begin in patches, which then show up in strong contrast to the portions of the coat which remain pigmented; or it may take the form of a gradual bleaching over the whole body. Young animals seem to show as much irregularity as adults.

There is some evidence to show that on the whole does whiten more readily (and retain the white pelage longer) than bucks. Years ago the late G. H. Kinahan found (*Land and Water*) that in Connemara in March he could tell bucks and does by their colour alone, and the conclusion reached at Kilmanock is similar.

Within the above limits whitening is dependent on temperature, being more prevalent in hard than in mild winters (see *Zoologist*, 1882, 107); but not always clearly so, since in some mild seasons a few individuals may attain to a conspicuous degree of whiteness.

At Kilmanock the white appears at no very regular period, but never before December, and sometimes later. Individuals seem on occasions to whiten slowly, but at other times so rapidly that to suppose that the change is caused by a moult is inconceivable; indeed I have found a moult on 9th November 1910, before the whitening season.

Having once whitened, an animal remains so until the next moult, which may be postponed until some time during the first half of May, and apparently is often late in animals which have whitened to an exceptional extent. The date of the spring change is very irregular, and I examined whitened hares in process of moult and changing back to brown, on 20th and 21st January 1910. A very white female in the Dublin Museum from Ballybrophy, Queen's Co., labelled February 1901, is also moulting from white to brown.

Irish Hares introduced at Vaynol, near Bangor, North Wales (see above, p. 329), are said to become more or less white as a general rule (Ed. of *Field*, 1st August 1891, 174). In Mull they do not turn white as readily as the Scottish Hares.

Thompson mentions a hare which, after having been white in winter, was easily recognised by its light colour in the following summer.

The **skull** is similar to that of *L. timidus scoticus*, but larger (see table of dimensions); it shows primitive characters in the flatter interorbital region, and less conspicuously elevated superciliary processes.

In the **teeth** the incisors are longer and heavier than in any other British Hare, though not so broad as in *europæus;* the molars are long and stout. The mandible (Fig. 48, p. 315) is consequently very deep, and the growing ends of the lower incisors overlap the anterior cheek-teeth. The above cranial and dental features are emphasised in the late pleistocene *L. anglicus*.

Exceptional variation:—Blackish or sooty varieties occur occasionally, and several instances are on record, *e.g.*:—one, Co. Kildare (Thompson); another, same county, December 1889, with the central dorsal region black fading into blackish grey on the flanks, but the sides of the mouth and a small space around the eyes normal (E. Williams, *Zoologist*, 1890, 70); one, described as "perfectly black," shot near Belturbet, Co. Cavan, in 1878 (Williams and Sons, *Zoologist*, 1878, 434); one, at Garrycloon, Ballina, Co. Mayo, 1892, examined by me at Williams and Sons; a breeding doe, weighing 8 lbs. 10 oz., now in the British Museum, purchased, Waterford, 7th January 1911; one in the Dublin Museum from Queen's Co.; and there have been others (see Dennehy, *Field*, 27th May 1905, 905).

A well-marked buff variety, first reported by A. Williams from the midlands, and also noticed in Galway (Millais), became numerous along the coast from Malahide to Balbriggan, Co. Dublin. The upper side is rich buff, the under side white, the eyes pale straw-yellow with a greenish tint, and the black ear-tips are absent. The variety appears to breed at least partially true, since mother and young have been taken together (E. Williams, *Zoologist*, 1890, 70-71); for this reason I named it *Lepus timidus lutescens* (see *Synonymy*), but the name has not been accepted, and the variety can hardly be regarded as of subspecific value. It crops up occasionally amongst the Irish Hares introduced into the island of Mull, and has been noticed amongst Scottish Hares at Tellyfour, Aberdeen (see Haggard, *Field*, 31st October, 693; Fenton, *Journ. cit.*, 21st November 1896, 814).

A permanently grey or whitish variety (of which a specimen is in the Dublin Museum), without black ear-tips, but with pigmented eyes, arose in Co. Armagh as the produce of a single white individual. This was first observed as a leveret in 1885, and in 1887 was netted and turned down at Castle Dillon, where, the same year (according to G. D. Beresford), it produced two leverets, one grey and white, the other white like the original. In 1890 there were seven hares, evidently bred from the white hare—six white, and one a parti-coloured grey and white animal. Four died during the winter and spring, and there were left in July 1891 three, the original hare, another white one, and the parti-coloured one already mentioned. These hares never changed colour, but always remained the same as when born. In 1891 no leverets were born, and the old doe was then about seven years old.

Both old and young may exhibit the white frontal spots already mentioned as occurring in the other British species of *Leporidæ*.

Sexual differences are very evident in this species, the males having the head comparatively thicker and shorter, and the ears apparently shorter than the females.

Local variation:—There is a general impression amongst sportsmen that hares inhabiting the mountains differ from those found in the plains, but little definite information is available. Kinahan, writing of Connemara, mentioned "the short, small hares that do not seem to care for running and always dodge about between the rocks and crags" in contrast to the "long springing sort, that will run when started" of the Banneobela range (*Land and Water*); and Whyte suggested that the hares of the heathery mountains of Galway are not identical with those of the green limestone (*op. cit. supra*). Further study on this and other kindred points is desirable.

Skull (range of five specimens of both sexes):—Occipito-nasal length, 91 to 98·6; condylo-basal length, 82 to 86; zygomatic breadth, 44·4 to 48·4; breadth at inter-orbital constriction, 22 to 23·4; breadth at post-orbital constriction, 14 to 17·6; breadth of brain-case, 32 to 33·8; nasals (measured diagonally), 39·4 to 42·8; greatest breadth of both nasals together, 19·4 to 22·1; length of diastema, 26 to 28·4; length of mandible, 73·4 to 74; length of maxillary tooth-row, 18 to 18·8; length of mandibular tooth-row, 18·6 to 19·2.

Weight (in pounds and ounces):—Fully adult females in good condition killed on the rich, low-lying pastures of Kilmanock, Co. Wexford, may reach 9 or a little more, the heaviest ever handled being nearly 9^4, but these weights are exceptional and, as shown in the tables, the average is much less. The largest bucks are lighter, the two heaviest being only 8. The above figures are probably true of lowland hares all over Ireland, since Pomeroy (*op. cit. supra*, p. 333) gives 9 as the limit for Galway, with good hares slightly exceeding 8, but a great many little over half that weight, especially on the heather, where Whyte also found them lighter than on the green hills (see *Field*, 25th July 1874, 87, a very similar note to Pomeroy's). From Monaghan, Kane wrote me that they "run to a great weight, sometimes 9 lbs. and even more." Sixty-three killed at Ballypatrick averaged 7, but in Glenarm Park demesne, both in Co. Antrim, they often reach 9 (Lord Antrim, per Robert Patterson). The introduced hares of Mull are also said to equal about the same weight; according to Millais they frequently scale 8, and the largest known 9.

Weights greater than 9 must be very rare, but Meade-Waldo informs me that in the winter of 1895 he received one (sex not stated) scaling 10, from Ards, near Letterkenny, Co. Donegal; Lord Antrim has known of a single one reaching a similar figure in Glenarm Park demesne, and these would appear to hold the record for the species.

It will be noted from the tables that several males of 6 and two females

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail.		Hind foot, with claws.	Ear.		Weight.	
		With terminal hairs.	To end of vertebræ.		To notch.	To nape.	Lbs.	Oz.
SPECIMENS FROM KILMANOCK, CO. WEXFORD (killed 17th Jan., measured 18th Jan. 1911).								
FULLY ADULT MALES:—								
1.	559	143	81	165	74	104	7	8
2.	533	133	82	159	71	95	7	0
3.	546	149	76	149	72	97	7	0
4.	546	124	75	159	75	95	7	0
5.	559	124	70	156	71	97	7	0
6.	559	133	80	152	76	108	7	0
7.	546	124	75	165	70	98	7	0
8.	559	140	77	168	75	98	7	0
9.	533	133	74	159	76	100	7	0
10.	546	118	70	159	79	102	7	0
11.	546	121	76	156	75	95	6	8
12.	..	133	81	152	71	96	6	8
13.	533	127	78	152	69	98	6	0
14.	546	133	74	159	71	100	6	0
Average (approximate)	547	131	77	158	73	99	6	13
YOUNG MALES:—								
1.	546	133	75	168	80	104	6	0
2.	533	118	71	149	69	92	6	0
3.	508	124	79	152	79	97	6	0
4.	521	121	74	149	75	95	6	0
5.	546	136	73	152	78	102	5	8
FULLY ADULT FEMALES:—								
1.	559	121	71	165	81	108	8	0
2.	533	111	77	156	81	101	8	0
3.	533	120	77	156	76	99	7	8
4.	533	110	70	159	75	97	7	8
5.	533	125	79	152	80	104	7	8
6.	559	112	72	159	79	100	7	4
7.	559	130	70	152	79	110	7	0
8.	546	112	72	152	69	94	7	0
9.	546	124	69	156	75	98	7	0
10.	546	118	65	152	79	107	7	0
11.	521	..	..	156	76	95	7	0
12.	533	108	66	156	72	109	6	8
13.	559	111	79	156	78	108	..	
Average	543	117	72	156	77	102	7	4
Average of 27 of both sexes	545	124	74	156	75	100	7	0
Approximate proportionate lengths of adults of both sexes, head and body being reduced to 100, and all other dimensions proportionally	100	..	13·5	28·6	13·7	18·3	..	
Leveret (sex uncertain), 7th August 1911, hind foot very well haired; ears much shorter than head	200	35	30	..	40	45	..	
Leverets, about 21 days old, born in captivity at Kilmanock	224	35	25	60	38	45	0 0	7 6·5
Weight at birth estimated at	.	.	..	..	..	..	0	2

N.B.—44 males killed by coursing at various dates, and not specially selected, averaged 6 lbs. 8 oz., with maximum 8 and minimum 5 (see *Irish Naturalist*, 1912, 234).

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail.		Hind foot, with claws.	Ear.		Weight.	
		With terminal hairs.	To end of vertebræ.		To notch.	To nape.	Lbs.	Oz.
SPECIMENS FROM KILMANOCK, CO. WEXFORD—*Continued.*								
YOUNG FEMALES:—								
1.	533	115	66	156	76	107	6	8
2.	583	105	72	156	70	99	6	8
3.	508	102	66	152	70	103	6	0
4.	521	112	69	152	73	110	6	0
5.	583	118	77	152	73	99	6	0
6.	583	121	77	152	71	108	6	0
7.	533	123	76	153	82	113	6	0
8.	483	78	56	140	69	97	5	0

N.B.—53 females killed by coursing at various dates, and not specially selected, averaged 8 lbs. 5 oz., with maximum 9 and minimum 6. Six of both sexes, specially selected as the largest amongst a number, 22nd February 1899, averaged 7, with maximum 8 and minimum 6 lbs. 5 oz. (see *Irish Naturalist*, 1912, 234).

of 6^8 were considered to be not fully adult, and an immature male of 7 is mentioned above, on p. 331.

Distinguishing characters:—The ochraceous or tawny, instead of smoky brown colour is at all seasons distinctive as between the Irish and the Blue Hare, while as between the Irish and the Brown Hare the same points of distinction may be used as those laid down for distinguishing the Blue Hare. The cranial characters are given above, on p. 333.

To show the difference between the two groups *Eulagos* and *Lepus*, a subadult Brown and an adult Irish Hare were photographed in the same position (Plate XXIII.). The specimens were chosen because they were of about the same weight, an adult Brown Hare being too large for purposes of comparison. In these two specimens the actual body length was about the same, but its depth was slightly greater in *europæus*, in which animal also the hindquarters appeared to the eye to be more massive. In *hibernicus* the head is markedly larger, both in length and breadth, besides being more rounded; the eye is rounder, the ears markedly shorter, but the dimension of head and ears together is slightly longer in *europæus*. Every part of the limbs is longer in *hibernicus*; and, to show that this is not peculiar to the specimen of *europæus* used for comparison, the corresponding dimensions of an exceptionally large and fully adult *europæus* are added for comparison. In not one dimension of limbs or skull did this large specimen exceed the much lighter *hibernicus*.

L. hibernicus is, except in head, a more finely built animal, with longer legs, lighter bone, and less massive body.

	L. hibernicus, Kilmanock, Co. Wexford.	*L. europæus*, Poynetts, Bucks. (A. H. Cocks.)	*L. europæus*, Capernoch, Dumfries. (H. S. Gladstone.)	*L. anglicus*, (Pleistocene of Ightham).	*L. anglicus*, (Pleistocene of Ightham).	*L. t. scoticus*, Capernoch, Dumfries. (H. S. Gladstone.)	Corstopitum specimen.
Sex	Adult Male.	Subadult Female.	Old Female.				
Weight, 16th Jan. 1912	7 lb. (weighed warm)	7 lb. (weighed cold)	about 9 lb. (weighed cold)	..	..	..	..
From tip of nose to end of claws of hind feet	711	711	..	..	..	..	.
From tip of nose to base of tail	520	520	..	..	..	..	..
From tip of nose to end of ears	203	209	..	..	..	..	..
Depth behind shoulder, measured in a straight line, not round the curves	152	165	..	..	..	..	..
The same, just before the thighs	139	139	..	..	..	..	..
Length of a hind foot (including claws)	149	143	..	..	..	..	..
Skull, extreme length	97·2	90·6	99·4	110	103	95·7	..
Humerus, do.	107·3	97	102·7	(Somerset)	115·8	105·8	..
Radius, do.	110·8	103·8	108·3	..	120·5	108·3	..
Ulna, do.	126·3	119·3	..	..	..	123	..
Femur, do.	128·2	119·7	124·6	..	140·9	127·5	..
Tibia, do.	145·8	135·7	143·6	154·6	145·5	145	152·7
Do., inarticular length (inner side)	140·2	130·9	138·3	..	..	139·6	146·6
Metatarsal III, length	56	50·8	53·5	59·7	55·2	55·2	..

The habits of this species probably do not differ much from those of the Scottish Hare. When accustomed to human beings, it becomes anything but timid, and at my own home there are few hours of the day or night when from one up to (occasionally) a dozen may not be seen grazing within a stone's throw of the house. Very often they will not take the trouble to retire on the approach of a human being, and their tracks show that in the night they wander quite close to the house and even ascend the hall-door steps. Even if chased by a small dog they will frequently sit bolt upright to reconnoitre their pursuer. It is a pretty sight when a party of these beautiful animals are feeding at close range in perfect confidence, and in spring their movements are particularly attractive. At that season they are unusually in evidence, and go through many antics—boxing, kicking, bucking, dodging, leaping sideways, sniffing at each other nose to nose, or rushing madly round in a circle. Then after a general scurry they settle down to feed, scraping away snow (if present) with their paws; or they may roll on their backs or stretch themselves at full length on the ground. In March 1909 two pursued a large domestic cat of colour somewhat resembling themselves; the pursuit was sustained so hotly across the lawn and through a shrubbery that more than one person witnessed it independently; a possible explanation may be that these were two males so blinded with "March madness" as to mistake grimalkin for a member of their own race.

The eyesight cannot be very good, at least not as compared with that of man, dog, or fox. Although a hare, when not lying in her form, will see and move away from a man while still several hundred yards away, she often does not notice a motionless observer, even if he is standing in the open, and will approach him quite closely without suspecting his presence. On such an occasion one has fed a little quite close to me, lingered to clean herself, and passed on without having perceived me. At other times individuals have been so near that their twitching nostrils were plainly visible.

In relative speed, activity, and endurance, the three British hares, when well fed and on suitable ground, are not known to differ widely, though, as might be expected, the Blue Hare is inferior when half starved in winter on a diet picked up on the mountains. William Thompson was informed that the only noticeable distinction between the Irish and Scottish Hares is that the former goes off faster from greyhounds than the latter, and is thus less likely to be killed at the first dash; but there are few opportunities of comparing these two species.

The Irish and the Brown Hares are more often seen together, since each of them has been introduced into the territory of the other. People who have observed them side by side seem puzzled to clearly distinguish their powers; and in England[1] the Irish are considered quite as good for coursing purposes as the local hares, as shown by the large number now exported.[2] At Trabulgan, Co. Cork, Brown Hares were for two seasons coursed side by side with the native hares, which the first Lord Fermoy believed that they outpaced until the greyhounds reached them, probably owing to their greater size and longer stride. But when closely pressed the Brown Hares were not nearly such good performers as the Irish, "as the latter turns in so much smaller space, is so much quicker off the turn, and is so very stout-hearted. She is never beaten until the greyhound has her in his mouth." This is a plausible view, and agrees with the anatomical distinctions between the two animals—the lighter body but longer legs of the Irish Hare.

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[1] As at Gosforth Park, Newcastle-on-Tyne, *fide* T. Snowdon; see *Irish Naturalist*, 1898, 76. Brown Hares introduced at Strabane, Ireland (see above, p. 329), are said to be, in comparison with the Irish, "bad soft runners" (D. Ker, *in lit.;* see also some notes in *Field*, 14th April 1888, 527).

[2] *E.g.* from Finnebrogue, Co. Down, see the late Major-General W. E. Warrand, *Zoologist*, 1895, 104.

As regards the powers of the Irish Hare when hunted by harriers, Mr Reginald Graham,[1] who turned down some at Norton Conyers in Yorkshire, believed them to be faster and stouter than the Brown Hare.

In actual speed all hares are, except on favourable ground,[2] very inferior to greyhounds and doubtless also to racehorses,[3] which are the only breed of horses capable of being brought into a fair comparison. It is therefore not surprising to find that the late Colonel Thornton, of Thornville Royal, who died in 1823, is credited with having ridden down a Brown Hare at Newmarket in the presence of a large concourse of people; and that the late Allan McDonogh, a noted steeplechase rider, many times on the Curragh of Kildare turned (presumably Irish) hares after a quarter of a mile's gallop on a chaser. The failure of Mr J. E. Harting[4] to overtake the hares of the Wiltshire Downs was no doubt due to the fact that his horse, although good, was "not a remarkably fast one." But a race between a horse and a hare must be regarded as a somewhat unsatisfactory contest, the result being largely dependent on the length of the course, the breed of the larger animal, and the character of the going.

My friend Capt. C. G. Cole Hamilton recently chased a Brown Hare with a motor car. The animal had become so confused that it rushed along a road at increasing speed, and kept ahead of the car until at 30[5] miles an hour it was

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[1] Evidently a Master of Harriers; see *Field*, 15th February 1896, 258.

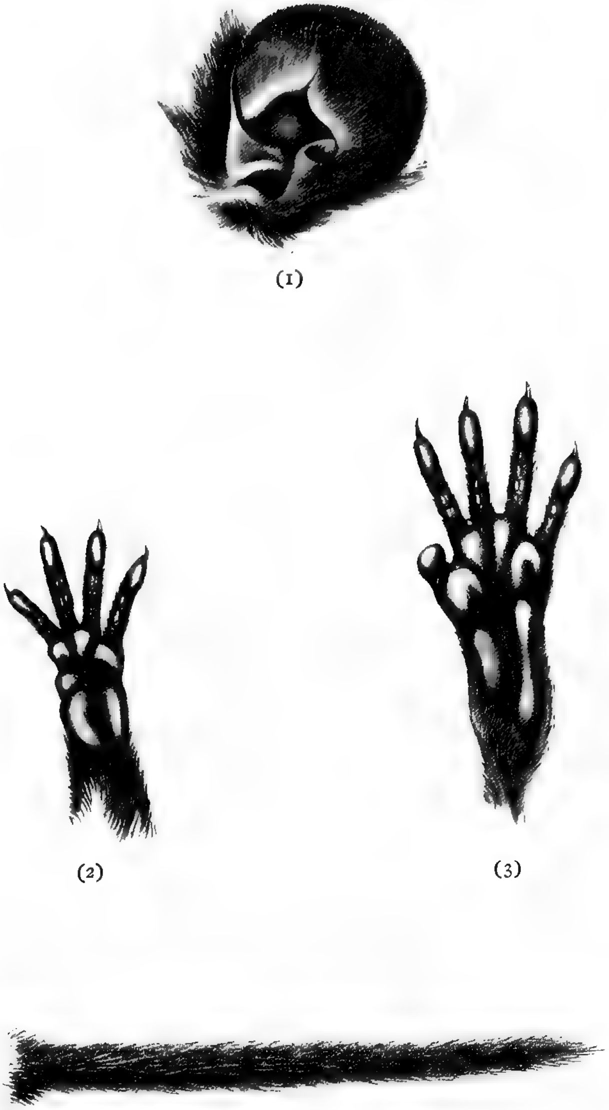
[2] *Cf.* above, p. 276.

[3] Ernest Thompson Seton (i., 231) concludes that not only hares but greyhounds yield in pace to a blood horse.

[4] For the facts in this paragraph, see *Field*, 29th August 1891, 332, and 6th February 1909, 214.

[5] According to my observations at coursing meetings, a hare can continue to run at her best pace for as much as 100 seconds, but she is frequently caught in about half a minute if unable to reach covert.

PLATE XXII.



(1)

(2)

(3)

(4)

THE DORMOUSE.

(1) LEFT EAR (3 times life size); (2) LEFT HAND, and (3) LEFT FOOT (both 2½ times life size); (4) SIDE VIEW OF TAIL (life size).

forced to slip out of the way to avoid being run over. I was myself witness of the attempt of a greyhound to race a car in which I was travelling. The dog was only left behind when the speed indicator reached 37[1] miles an hour, and, allowing for the superior pace to be expected from a highly trained animal habitually used for coursing, a maximum rate of 40 to 45 miles an hour may be credited to a greyhound and of about 30 miles an hour to a hare. The pace of a hare is thus about three-fourths that of a greyhound, and nearly as fast as the average Derby winner, that race being run at an average speed of 30 to 35 miles an hour; though, were it possible to ascertain for comparison the racehorse's best sprint for a quite short distance, a very different result might be expected.[2]

In Fig. 49 are shown diagrammatically three types of the spoor of Irish Hares. When travelling slow (A) three of the four feet fall more or less in a straight line, and are about equidistant from each other; one hind foot is in advance, the other a little to a flank and in rear, with the two fore feet following. There is a distinct gap between each phase or group of four. As the pace increases (B) the distance between the phases is lengthened, and the phases themselves are, as it were, pulled out. At still greater speeds (C) the action changes, and each pair of fore and hind feet, markedly the latter, come down almost simultaneously; the phases thus are altered, so that the spoor resolves itself into a series of roughly paired marks at distances which are alternately double and half of each other, as explained below. The hind legs appear to propel the animal forward about twice as far as the fore legs. The diagrams show the somewhat surprising result, that the motion of the legs is more continuous and approximates more nearly to that of a wheel when the pace is slow than when it is fast; in the latter case progression resolves itself into a series of leaps, in which the fore legs try to bridge over the distance traversed by the body at each effort of the powerful hind legs, and always touch the ground (unless the

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[1] I have seen a large mongrel terrier attain about 25 miles an hour.

[2] Much interest is also taken in the speed of foxes, cheetahs, and wild asses, the powers of the latter having been known to Arrian, who wrote in Greek about the end of the first century B.C. (*op. cit. supra*, p. 244); they are mentioned in the articles on Fox and Horse.

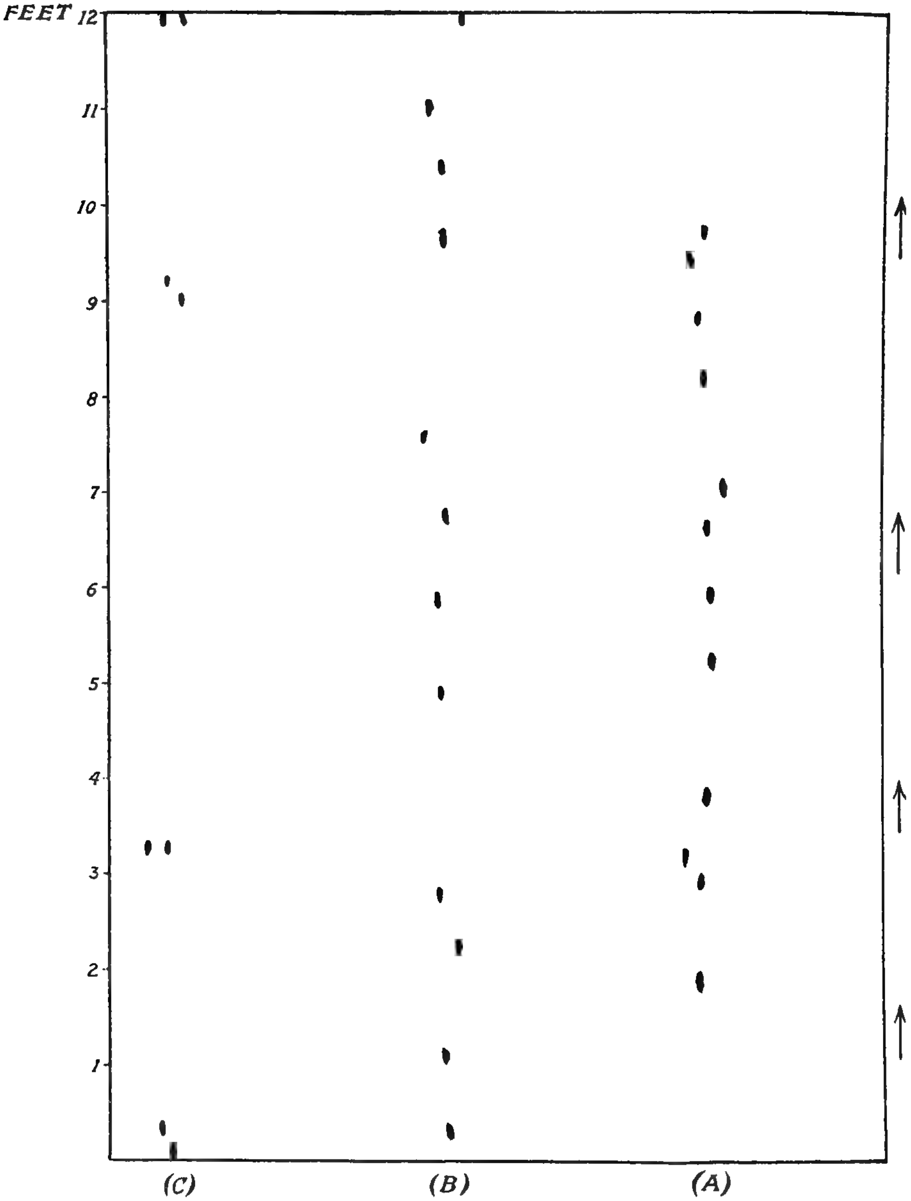

FIG. 49.—DIAGRAM OF SPOOR OF IRISH HARE, as measured on shallow snow at Kilmanock, Co. Wexford, 5th February 1912. The arrows indicate the direction.

(*A*) Slow. (*B*) Faster. (*C*) Fairly fast.

Length of mark of a fore foot in *A*, 3 inches, in *B*, 4 inches; ditto of a hind foot, 4·5 (*A*) and 5 (*B*) inches (length of a fore and hind foot in Rabbit, 2 and 3 inches respectively). Extreme width of track made by two fore feet, 2 inches, and by two hind feet, 5 inches.

pace is being retarded or accelerated) at two-thirds of the distance from hind-foot mark to hind-foot mark measured forwards. The order of the hind feet may be changed as in B; the fact that they move unevenly is visible to the eye when the pace is slow, and I have seen one lifted up after the manner of a terrier dog, the hare travelling for a short distance on three legs.

I have measured a series of leaps measuring approximately 90,[1] 46, 90, 45, 86, 42, 62, 44, 86, 47, 60 and 120 inches, the average of the long and short leaps being 89 and 47 inches respectively. These do not pretend to represent the extreme speed of the animal, in which case much longer distances would no doubt be covered. I have not noticed what Mr Thompson Seton calls "spy-hops," that is, extra big leaps made for purposes of observation.

In the particular tracks figured the "triangles" of the theoretical track (see p. 169) are not so evident as in the tracks of rabbits figured above on p. 220.

It is obvious that in order to leave the spoor described above, the animal can only progress by alternate contractions and extreme extensions of its whole body, the muscles of which are thus utilised to assist those of the limbs. This method of progression has been shown by Mr Edward Muybridge[2] to be that of the greyhound, but the spoor of the Irish Hare indicates an extreme development of the action.

When merely wandering about at ease the length of leap may decrease until the animal halts and footmarks overlap.

The above figures may be compared with the 15-feet leaps of the Brown Hare, as described in the article on that animal,[3] as well as with Dr R. W. Shufeldt's notes[4] on two American species, of which one, the white-sided "Jack Rabbit,"[5] clears at ordinary times 48 inches, but if pressed, 144 to 156 inches;

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[1] The combined length of the two fore and two hind feet should be deducted in order to arrive at the true length, since in each hind foot there is a space of about 150 mm. of leverage and variation of fulcrum, and in the fore limb, from the carpus to the claws (the function of which in progression is not to be underrated) about 75 mm. of leverage are found, being a total of about 225 mm. for each lateral pair of feet and the double of that for the action of all four feet. (See Joseph Gamgee, "On the Action of the Horse," *Journ. Anat. and Phys.*, May 1869, 375.)

[2] *Descriptive Zoopraxography*, 1893, 41.

[3] See above, p. 287.

[4] *Zoologist*, 1888, 259; see also Editor, *Field*, 9th November 1895, 786.

[5] *Lepus callotis callotis* (Wagler).

while for the other, a cottontail,[1] which is in size about the equal of our own Rabbit, the corresponding figures are 24 and 72 to 84 inches; it is not stated how these measurements were made. According to Mr Thompson Seton,[2] the "Snow-shoe Rabbit" of Manitoba[3] clears 8 or 10 feet at a bound, and makes four bounds in a second, thus attaining a rate of over 26 miles an hour. But this is a small animal weighing only about 3 lbs. The much larger white-tailed Prairie Hare,[4] the weight of which averages 7 or 8 and may reach 12 lbs., is said to clear commonly 18 to 21 feet, and races along at nearly 30 miles an hour.[5] As in the case of Dr Shufeldt's observations, it is again not stated exactly how the measurements were made.

The Irish Hare if pursued frequently "goes to ground," but it digs no burrow for itself. I have seen one when coursed disappear into a rabbit's burrow and thus save its life,[6] and on several occasions leverets have voluntarily done the same thing, or have concealed themselves in hollow tree-trunks;[7] I also knew two leverets which habitually lived in a rabbit's burrow.[8] My friend, Capt. T. S. Blackwell, once bolted a hare with a ferret in the King's County; and in the summer of 1912 my keeper thus bolted eight leverets, each aged about a month, from two burrows.

In mountains the habits are thus described:[9]—They "take to natural fissures in the rocks, or to natural courses, called by the natives water-brakes, formed by the percolation of the water through the peaty formation overlying the rock or other hard subsoil, often to a depth of several feet. In many localities, as for instance in the Bannermore chain in Donegal, where there is little covert, the hares become nearly as subterranean in their habits as rabbits. In these holes or crevices they seek safety from their enemies or shelter from bad weather, coming to the entrance of their 'burrows,' if such they may be termed, to bask in the sun,[1] their 'seats,' as they are termed, being clearly marked. It is supposed that hares took to this habit to escape from their chief enemies the eagles, formerly abundant in these mountains. . . ."

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[1] *Sylvilagus*, sp.? [2] i., 636. [3] *L. americanus* of Erxleben.

[4] *Lepus campestris* of Bachman.

[5] Captain Lewis, quoted by Thompson Seton, i., 666.

[6] There is a similar note from Co. Antrim by an anonymous writer, "R. A. A.," in *Field*, 18th July 1891, 88.

[7] *Irish Naturalist*, 1896, 119. [8] *Journ. cit.*, 1901, 73.

[9] "Aquarius," in *Field*, 8th February 1896, 185.

In the above quotation it is not implied that this hare may dig its own burrow. That suggestion was, however, made by S. G. Otway, who stated[2] that when introduced to the sandhills of the Mullet of Co. Mayo, the hares found that to obviate being buried by the sand during the storms of winter they must needs burrow or leave the district. Accordingly they made horizontal holes, perforating a high narrow sandbank from side to side. Sitting at the windward entrance they faced the storm, shifting their position backwards as the wind blew the sand away. The above story savours of romance, but it may well be founded on fact, since it is possible that the hares occupied the deserted habitations of rabbits. It would not be indeed surprising to find Irish Hares burrowing if placed in exceptional situations and amidst scarcity of cover. During the winter of 1911-1912 a number scooped out "forms" for themselves in an arable field of clay soil at Kilmanock, and lay with their backs sheltered by sometimes fully 6 inches of excavation.

This hare swims as well as its allies, and when frightened ventures to face a branch of the tidal estuary of the river Suir at Kilmanock, the width of which may be nearly a hundred yards across near its mouth. The ears are then laid back as when running at high speed, and lie close to the water. In Connemara Mr Harding Cox[3] found hares on the islands of Lough Inagh, and they were always ready, if disturbed, to cross the several hundred yards of often rough water intervening between them and the mainland. The above records relate only to frightened animals, but a friend of Thompson's observed one of its own free will enter and swim across a deep pool of a mountain stream, although a short way lower down the crossing was easy. A remarkable instance of swimming was that of a doe which, in order to attend to the wants of three leverets, swam every night to an island on an artificial lake.[1]

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[1] Or, perhaps, to avoid the wet mud of the floor—see T. P. Tomes, *Field*, 25th January 1896, 139.

[2] *Ann. Nat. Hist.*, v., 362, 1840.

[3] *Field*, 22nd September 1906, 540.

Occasionally these hares lie out so close to the sea that it would seem to be not unusual for them to be cut off and to have to regain the shore by swimming. Thompson states that he twice in one day came upon hares resting on rocks usually isolated for at least half of every twelve hours.

The breeding habits, so far as has been ascertained, are similar to those of other hares. At Kilmanock young leverets may be found, like rabbits, at almost all times of the year,[2] so that the does must have several litters each season; and in fact Thompson found that some kept in an enclosed yard in Belfast produced young three times in a year. That writer believed that there are five litters during each season. At Kilmanock the majority of leverets begin to make their appearance in March, that is not quite so early as young rabbits.

The usual number of young was stated by Thompson to be three, which agrees with my own observations, no instance exceeding that number having come under my notice, while in three cases I found only two. Thompson was, however, informed by two gamekeepers, that they had, although rarely, observed four, and his friend William Sinclaire took six out of a doe weighing 8 lbs. in May.

As in the case of other hares, the leverets are seldom found lying together in one nest, because they soon either disperse of their own accord or are separated by their mother. But it is probable that all the members of a litter are dropped in the same place, where, indeed, they may occasionally be discovered. One instance of three having been thus encountered together has come within my personal knowledge, and two others have been reported to me. On one occasion my gamekeeper kept the leverets under observation, and he found them on each subsequent day farther apart until he lost sight of them altogether. It seems likely that the young of a litter, although occupying separate forms, may meet and fraternise during their hours of activity. The two leverets to which I have already alluded as having their home in a rabbit's burrow, always grazed close to each other, and when alarmed ran to the same place of refuge.

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[1] H. C. Dent, *Field*, 14th June 1890, 892.

[2] The following dates are taken at random from MS. notes, all made at Kilmanock:—female suckling, 20th January; rabbit-sized leveret, 25th January; female in young, 14th February; recently born leveret, 27th August; three embryos, October; this practically covers every month except July and September, there being no need for records from March to June.

Thompson saw the young taken from their mother with their eyes open and able to run within an hour of their birth; and I can corroborate this precocious activity. Those born of captured dams readily learnt to drink milk from a saucer, but were able to dispense with it in about twelve days. In one case, when the leverets were allowed to remain with their mother, they throve very well, and she soon became very energetic in defending them with teeth and claws. But her affection must have undergone rapid cooling, for on about the twenty-first day they lay killed and mangled, thus probably indicating that period as representing the limit to which the parental love of the hare can be extended.

I have twice in spring seen a hare chasing crows from a field, as if she resented their proximity to her young; but, although the squealing of a leveret should make an efficient natural call, it does not summon the mother to the rescue when the aggressor is a man.

Although hares are polygamous, two may often be seen grazing in company as if paired, and sometimes several such couples have been under my observation at the same time. I have watched two thus resting together for some time under the shade of a tree, one of them basking and rolling in the sun. If not merely a temporary arrangement, it is possible that the couples consisted of leverets which had remained together from their babyhood.

Irish Hares are to a certain extent gregarious, and when numerous may even congregate in parties. This may be due to the instincts of the sexual season, but it is sometimes very noticeable in winter. Thompson found it a very marked characteristic in the north of Ireland, and he repeatedly saw from one to three hundred moving together in one drove like deer. This herding together was not the result of semi-domestication, but was exhibited in a perfectly wild state when the animals were abundant. In the south of Ireland

I have observed the same propensity and can thoroughly corroborate Thompson, although I have not seen so many hares together as he did. Probably it is the natural consequence of the animals being very numerous.

The scream of the Irish Hare when in pain has not been distinguished from that of other species.[1] When newly captured and frightened or annoyed it is almost as noisy as a little pig.

The food of this species is not peculiar. Like the Brown Hare it destroys the bark of trees, and is fond of the tender shoots of many conifers. Thompson states that it has a predilection for the bark of the oak and that, if it visits a garden, the delicate leaves of pinks and carnations are, together with parsley and young plants of cabbage, broccoli, and cauliflower, its favourites.

Its flesh is always accounted excellent for the table.

SIMPLICIDENTATA.

These, the great majority of rodents, are characterised by the possession of a single pair of upper incisors, the enamel of which is confined to the anterior surfaces. The distance between the maxillary and mandibular tooth-rows being approximately equal, the motion of the jaws in eating is longitudinal or oblique. The incisive foramina are distinct, and not posteriorly confluent, and the bony palate is never reduced to a narrow bridge between the premolars. The fibulæ do not articulate with their calcanea.

MUSCARDINIDÆ.

DORMICE.

These are small animals of rat- or mouse-like appearance and wide distribution, mostly in warm countries, from England to Japan and from central Sweden through Africa. They are unknown in America, either in past or recent times. They therefore probably originated in the Old World, where they are of ancient standing, having existed before the separation of China and Japan, and of Europe and Africa, at least as far back as the upper Oligocene, as well as during the Miocene and Pliocene of Europe; a well-known form, named *Leithia melitensis* by Leith Adams, is found frequently in the Pleistocene of Malta.

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[1] Thompson Seton's description (i., 661) of the "loud coarse squealing" of a captured Prairie Hare (*Lepus campestris*) as being not unlike the "caw, caw, caw" of a crow, is good also for the Irish Hare.

Dormice are inhabitants of shrubs or trees. They have long, hairy, often bushy tails; large, prominent eyes; well-developed but not long ears; short fore limbs; and prehensile hands and feet. The clavicles, tibiæ, and fibulæ are as in the *Muridæ*.

Besides the common *Muscardinus* of Britain, there are in Europe three other genera, all differing from *Muscardinus* in having simple stomachs. Of these, *Glis* includes the Fat Dormouse, known to the Germans as *Der Siebenschläfer*, and to the French as *Le Loire;* when full-fed in autumn, it was considered a great delicacy by the ancient Romans. There are several other forms; all grey squirrel-like animals, about as big as rats, with bushy distichous tails; their large molars have flat crowns with complex enamel folds. They are found from the Atlantic coasts of central and southern Europe to Asia Minor, and from North Germany and Russia to Sicily, Sardinia, and northern Spain. *Eliomys* includes the Garden Dormouse, *Der Gartenschläfer* of the Germans, *Le Lérot* of the French, which, with other species, range from Belgium to Asia Minor, and from northern Germany to northern Africa, including the Balearics, Sardinia, and Sicily; they resemble *Glis*, but have the head conspicuously marked with black and white; tufted, black-banded, distichous tails; and small molars with concave crowns and indistinct enamel folds. *Dyromys* (instituted by Thomas, *Ann. Mag. Nat. Hist.*, Nov. 1907, 406, for *Muscardinus nitedula* of Pallas, 1778 = *Myoxus dryas* of Schreber, 1782) presents characters intermediate between those of *Glis* and *Eliomys*. It comprises forms distributed from Switzerland, eastern Hungary, and Greece, through Asia Minor to central Asia.

Although naturally vegetable feeders, many dormice have insectivorous propensities, and will eat birds or eggs; in other respects their habits appear to be somewhat similar to those of *Muscardinus*, as described below.

The tail is very brittle in some forms, as in *Eliomys*, and breaks off, if seized, like that of a lizard, to the great advantage of the escaping animal (see Helm, *Zool. Garten*, July 1887, 217-219; *Zoologist*, 1888, 14-16). Thomas has shown (*Proc. Zool. Soc.*, London, 1905, ii., 491-494) that these dormice further resemble lizards in being able to regenerate their broken tails, and suggests that this power may be common to "all species," but it does not yet seem to have been demonstrated for *Muscardinus*.

The dormice have been associated with the squirrels on account of their climbing habits, and as often with the mice and rats on account of their general external resemblance and certain peculiarities of structure. But they have no close affinities with either family, and stand naturally by themselves as an intermediate group (see Forsyth Major, *Geol. Mag.*, November 1899, 492-495), being absolutely differentiated from both squirrels and mice by the number and structure of their molariform teeth, and from all other rodents in the absence of a cæcum to the large intestine. Their murine appearance may evidently be due to convergence, and is not necessarily indicative of relationship. Although climbers, they are not by that fact brought any nearer to the squirrels, and there are many arboreal forms amongst the murines. Their feet also are distinct from those of the squirrels, in which the claws are more prominent, whereas in the dormice the small claws but long digits with swollen pads enable the whole hand to be used as a grasping organ, and also break the shock of a jump.

These thickly padded feet are, however, strongly suggestive of the harvest mice (*Micromys*), as are also, to a certain extent, the ears, the valves of which are more complicated in structure than those of typical mice or of squirrels. But here, again, convergence, and not any true relationship, may be supposed, the climbing habits of *Micromys* and of *Muscardinus* being somewhat similar.

Dormice fill a quite different rôle from that of the squirrels, usually restricting themselves to creeping about in bushes and undergrowth, and not ascending high trees. They are also both more sedentary and more sluggish, and the European forms, at least, enter a deep hibernatory sleep in winter.

GENUS MUSCARDINUS.

1829. MUSCARDINUS, Jakob Kaup, *System der Europäische Thierwelt*, i., 139; based on *Mus avellanarius* of Linnæus.

Synonymy and **classification**:—The genus presents an instance of the modern tendency of restriction. It now includes only the common *M. avellanarius* of England, with its representatives in continental Europe; the larger dormice of Europe having been segregated in the genera *Glis*, *Eliomys*, and *Dyromys*.

The genus is poor in species and restricted in **distribution.** It ranges only from Wales to Asia Minor, and from central Sweden to the northern coasts of the Mediterranean, with Sicily; it is not known from the Iberian or Balkan Peninsulas.

Four species are recognised, including *M. avellanarius.* My *M. pulcher* (*Ann. and Mag. Nat. Hist.*, November 1898, 423), a brilliantly coloured form,[1] with a spot of cream-colour in front of each ear, is found in Italy from Sienna to Rome and Naples. Dehne's *M. speciosus* (*Algemeine deutsche Naturhist. Zeitung*, Dresden, N.F., ii., 1856, 180), described from Tursi in Basilicata, south Italy, may represent a form identical with Sicilian specimens, which are remarkable for their deep colour, but are very little known; or it may prove identical with *pulcher*, in which case that name must give place to *speciosus. M. trapezius*, described by Miller (*Ann. Mag. Nat. Hist.*, January 1908, 69) from Khotz, near Trebizond, Turkey in Asia, has small, nearly circular auditory bullæ; it is probably the form recorded by Nehring from Scutari, and is stated by Satunin not to reach Transcaucasia.

The genus was made known from the post-Pliocene of Germany by Nehring (*Beitr. z. Anthrop. u. Urgesch. Bayerns*, 1879, ii., 234); in Britain it has been found only in the **Pliocene,** Hinton having seen a single tooth from the Forest Bed; and it is represented by *M. sansaniensis* (Lartert) in the middle Miocene of continental Europe (see Forsyth Major,

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[1] As noticed by Brookes, *Natural History of Quadrupeds*, 1763, 293.

op. cit. supra, p. 350). It is a highly specialised offshoot of an ancient family, the absence of which from Ireland, Norway, and Spain, but presence in Sweden and Great Britain, stamp the present stock as recent immigrant to western Europe with low powers of dispersal, since it has not yet had time to occupy Norway or cross the Pyrenees. Its absence from Africa and the Mediterranean islands, except Sicily (where it may have been introduced), shows that it has not come from the south, whereas its presence in Italy and Sweden points to an existence of long-standing in central Europe antedating the birth of the Alps and of the Baltic. It may thus have originated somewhere in Europe, perhaps in Germany or near the Alps, as suggested by Scharff.

These dormice are all mouse-like rodents, characterised by a thick, compact body, warmly clothed with soft, dense fur; long, bushy, cylindrical, slightly prehensile tail; climbing hands and feet with rudimentary thumbs and short first toes.

They are gentle creatures, living in pairs or small colonies in thickets, where they build globular nests, in which they sleep by day, venturing abroad only at night. They are of more exclusively vegetarian diet than the members of the other European genera. During the summer months they produce two or more litters of blind and naked young, become very fat in autumn, and then fall into a deep sleep lasting, with brief intervals, until spring. They are of sedentary habits, a fact which no doubt accounts for their being without scent-producing glands. The same quality makes them very acceptable in captivity, where they thrive well and readily breed and rear young.

The brownish or ochraceous yellow coloration recalls that of the so-called "chestnut" horses, and suggests partial albinism. Judging from the young, it is a development from a former more mouse-like tint. It runs to bright buff in the Italian *M. pulcher*, can hardly be protective, and there is no reason to suppose that it is used for warning purposes.

In the **stomach** the cardiac extremity of the œsophagus has thickened glandular walls.

There are eight **mammæ**, arranged as:—pectoral 1—1, abdominal 1—1, inguinal 2—2.

The **skull** resembles that of the *Muridæ*, but the jugal bones are larger, sometimes recalling those of the *Sciuridæ*; the angular portions of the mandibles are bent outwards at their centres so that their lower borders bear distinct secondary angles.

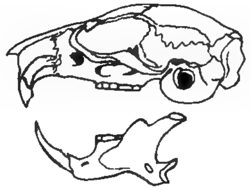
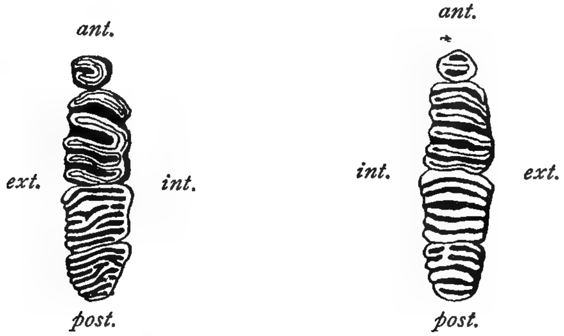


FIG. 50.—SKULL OF *Muscardinus avellanarius* (1½ times life size).

There are twenty teeth, arranged as—

$$i\,\frac{1-1}{1-1},\quad c\,\frac{0}{0},\quad pm\,\frac{1-1}{1-1},\quad m\,\frac{3-3}{3-3}=20.$$

The premolars are small and single-rooted. The molars decrease in size from the anterior to the posterior, the anterior being distinctly the largest, and having five roots. All the cheek-teeth have flat, highly polished surfaces, through which show complex, transverse or slightly oblique enamel folds, numbering usually $\frac{2—5—7—6}{3—6—6—6}$ in the various teeth. The result is a highly complicated, rasp-like surface, unique amongst mammals, but resembling in some few respects the teeth of elephants.



Right upper. Right lower.

FIG. 51.—CHEEK-TEETH OF *Muscardinus avellanarius*, diagrammatic and magnified.

THE DORMOUSE OR SLEEPER.

MUSCARDINUS AVELLANARIUS (Linnæus).

1666. MUS AVELLANARUM, Christopher Merrett, *Pinax*, 167; Walker; probably from Aldrovandus, *De Quadrupedibus Digitatis Viviparis*, ii., 439, 1637.

1693. MUS AVELLANARUM MINOR, John Ray, *Synopsis Methodica Animalium Quadrupedum*, etc., 220.

1758. MUS AVELLANARIUS, Carolus Linnæus, *Systema Naturæ*, x., 62; xii., 83, 1766; described from Upsala, Sweden; Berkenhout.

1777. SCIURUS AVELLANARIUS, J. C. R. Erxleben, *Systema Regni Animalis*, Gen. 39, sp. 16, 433.

1788. MYOXUS MUSCARDINUS, J. F. Gmelin, *Systema Naturæ*, I, 156; renaming *Mus avellanarius*; Bingley; Turton; Kerr; Donovan.

1791. GLIS AVELLANARIUS, J. F. Blumenbach, *Handbuch der Naturgeschichte*, ed. 4, 70.

1820. MYOXUS AVELLANARIUS, A. G. Desmarest, *Mammalogie*, 295; Shaw; Fleming; Jenyns; MacGillivray; Bell, edd. i. and ii.; Keyserling and Blasius; Blasius; Clermont; Fatio.

1843. MUSCARDINUS AVELLANARIUS, J. E. Gray, *List of the Specimens of Mammalia*, 133; C. L. Reuvens, *Die Myoxidæ oder Schlæfer*, 1890, 69; Flower and Lydekker; Lydekker; Aflalo; Thomas, *Zoologist*, 1898, 100; Johnston; Winge; Trouessart; Millais; Miller.

1869. "MUS CORILINUM, Schreb. Sæugeth. iii., p. 835, *n.* 14"; Victor Fatio, *Vertébrés de la Suisee*, i., 183; but the name is not found in Schreber, and apparently originated in Albertus Magnus, *De Animalibus*, lib. xxii., 182 (ed. of 1519).

1900. MUSCARDINUS AVELLANARIUS TYPICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.* (London), 6th February, 86 = *M. avellanarius avellanarius* (Linnæus).

1900. MUSCARDINUS AVELLANARIUS ANGLICUS, G. E. H. Barrett-Hamilton, *loc. cit.*; described from Bedford Purlieus, Thornhaugh, Northamptonshire, from a specimen in full, rich winter pelage; Trouessart.

Le Muscardin of the French; *die Haselmaus* of the Germans (not *le Loire* = *der Siebenschläfer* = the Fat Dormouse = *Glis glis*; not *le Lérot* = *der Gartenschläfer* = the Garden Dormouse = *Eliomys quercinus*).

Synonymy and History:—There is no difficulty about the proper technical name for this little dormouse, which appears to have been first described by Aldrovandus in 1637. Previous to that date it was probably passed over or confused with the larger species found in continental Europe. Topsel (1658) was evidently not acquainted with it, for his chapter "Of the Dormouse" refers to *Glis*, and that "Of the Nut-mouse, Hazel-mouse, or Filbird-mouse" is headed by a drawing of *Eliomys*, and clearly deals with that animal. Although known to Merrett and Ray, it was not mentioned by Gilbert White. It appears in all Pennant's editions, and in 1758 was figured by Edwards (*Gleanings of Natural History*, chap. lvi., pl. 266, opp. p. 118).

Terminology:—*Dormouse*, plural *dormice*, from Middle English *dormous*, spelt also *dormows* or *dormouse* (15th century), is usually derived from *dorm*, used as verb and substantive in the north country, Yorkshire and Derbyshire = to doze + mouse = "doze-mouse." Although probably of earlier date, it is not known before 1425 (see *N. E. Dict.*). The word is applied also to bats, as in Gloucestershire (*Dial. Dict.*).

There being only one British species, there is no need to use an adjective to distinguish our Dormouse; but it is often called the

"Common Dormouse," and by Bewick "The Lesser Dormouse," the latter, having regard to continental species, being a quite appropriate name. Pennant calls it "The Dormouse."

Local names (non-Celtic):—*Chestlecrumb* of South Devon (*Dial. Dict.*); *derrymouse* of Devon (Bellamy), *dorymouse* of Hampshire and Cornwall (*Dial. Dict.*), and *dozing-mouse* (Forbes), are no doubt forms of 'dormouse'; *seven-sleeper* of Warwick, Hampshire, Somerset, and Devon, a term also applied to any hibernating animals, as bats, and to moths (*Dial. Dict.*), with the common German name for the Fat Dormouse, *Der Siebenschläfer*, had its origin in "The Seven Sleepers of Ephesus," a popular legend of the Middle Ages; *shrew* of West Yorkshire (*Dial. Dict.*); *sleeper* of Ray (1693), and of many districts, *e.g.*, Shetland, Yorkshire, Northampton, Shropshire, Hertford, East Anglia, Kent, Buckinghamshire, Sussex, occurs also as *slapere* (*Dial. Dict.*); *sleep-mouse* of Berkshire, Hampshire (*Dial. Dict.*), and Surrey (Adams, MS.); *sleepy-mouse* of Buckinghamshire (Cocks, MS.).

(Celtic):—Although the animal is unknown in Ireland, Scotland, or the Isle of Man, the dictionaries give a number of names for it in the local dialects. These are either compound, such as the Manx *cadlag-gheurree* = 'winter-sleeper,' or general names for wild mice. There is naturally much confusion over the names of small mammals, the distinctions between which are imperfectly known; for instance, the Welsh *pathew* is also applied to other mice (Caton Haigh; Forrest).

Welsh:—*pathew*; cf. *cyn dewed â pathew* = 'as fat as a dormouse,' and *nid esmwyth ond pathew* = 'nothing so sleek as a dormouse'; *bathor*.

Cornish:—*bat* (Pryce).

Distribution:—This Dormouse has a rather restricted distribution, being known only from about 58° N. lat. in wooded districts of Sweden to the Alps, and from Wales at least to Galicia. It is not found in the Iberian (Cabrera, *Ann. and Mag. Nat. Hist.*, February 1900, 194) nor Balkan Peninsulas, and in Italy, Sicily, and Asia Minor is represented by other closely allied species. It ascends to 2000 feet in the Hartz Mountains (Blasius), and to over 4500 in the Alps (Fatio); Hungarian specimens in the British Museum were taken at about 3000 feet.

Where there is plenty of undergrowth, it is a common animal in **England**, south of the Midlands, including the Isle of Wight. It is widely, although locally, distributed in Wales, the western English counties, and much of the north of England, but is rare in the Midlands and strangely absent from some of the counties of the eastern plain. It does not reach the Scottish border, and the northern limit of its range is probably the county boundary between Durham and Northumberland. Even in districts where it is common, it capriciously affects certain localities to the entire exclusion of others in the near neighbourhood. Local decrease has been reported in Middlesex

(Millais); Surrey (Dalgliesh, *Zoologist*, 1906, 172; 1908, 182); Devon (Rope, *Zoologist*, 1885, 201-213, a very useful article); and Cornwall (Clark); but this may be due to the demand for captives.

In Essex it is widely distributed on suitable ground and common right up to the southern banks of the Stour (Laver), but unknown north of that river, being found only in the west (Tuck, *MS.*), and most commonly in the south-west, of Suffolk (Laver, *MS.*); Rope records it from near Ipswich, but on slender evidence. It is even scarcer in Norfolk, where, although several times mentioned [1] between 1830 and 1840, Southwell was unable to report its recent occurrence, except in the south-eastern parishes of Gillingham, Geldestone, and Stockton. In these it is common, but there was an undoubted introduction from Surrey about 1844, from which the local colony probably sprung.

Having regard to its undoubted scarcity in the neighbouring counties, the evidence is against its having been recently indigenous to Norfolk. It is scarcely better known in Lincoln; Cordeaux, although not denying its occurrence, informed Rope (*op. cit.*) that he had never met with it in the county; the sole record is that of Rudkin (*Field*, 24th May 1884, 702), who reported it from woods in the south-west, especially between Grantham and Bourn. Rudkin's observation is supported by Bolam's statement (*in lit.*), that in the years 1874 to 1877 he used occasionally to see dormice about Uppingham, Rutland.

In Leicester Browne reported it as rare; in Nottingham Whitaker could only point to two colonies in a single wood (Rope, *op. cit.*), and Lowe informs me that there is no specimen in the town museum; for Cambridge a single nest only is known, taken in 1883 near Newmarket (Rope); but these three counties and Huntingdon must surely contain some dormice, since the animal is known in Northampton (Lilford, *Zoologist*, 1885, 257; a specimen in the British Museum is from Thornhaugh, between Stamford and Peterborough), and it is plentiful in the neighbouring counties to the south. In Bedford Steele Elliot writes me that its presence is doubtful, and that, although reported from woods near Milton Bryant by Woods in 1856 (see *Zoologist*, 1885, 204), it must be extremely uncommon, even if it occurs at all. In Derby it is reported to be rare (Jourdain); while in Cheshire, perhaps, in correspondence with the scarcity of hazels, it is rare except in the extreme south, where it is more frequently met with and may be common (Coward). It is well known in all the western counties, including Monmouth (Evansen, *MS.*; Phillips, *MS.*), excepting the hilly and north-western portions and the marshy pastures bordering the Severn, both of which districts are quite unsuitable to its wants (Banks, *MS.*). It is frequent in Stafford (Masefield, *MS.*) and Shropshire (Forrest), as it must also be in the parts of Leicester, Derby, Warwick, and Worcester adjacent to Sutton Coldfield, Birmingham, for in that locality Steele Elliot writes of it as a familiar animal; but there are other records for these counties and for Hereford (Rope).

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[1] The brothers Paget (*Nat. Hist. of Great Yarmouth*, 1834, 2) stated that it "is occasionally seen in small woods"; J. M[acGillivray] in a "Sketch of the Natural History of the Neighbourhood of Norwich" (*Edinb. Journ. Nat. Hist.*, ii., February 1839, 3-4), named it "among the less common quadrupeds . . . these I saw but seldom"; and Southwell was informed that it was known about 1835 to 1845. But Lubbock (*Fauna of Norfolk*, 1845), although accepting the authority of the Pagets, was unable to confirm the statement, nor was Southwell (*op. cit.*, ed. of 1879, 11; also *Field*, 29th March 1884, 447) after twenty years' observation and enquiry.

In **Wales**, including Anglesey (Forrest), there is no county with a negative record, so that the animal is widely distributed. But, while scarce or very rare in Carnarvon (Forrest), it seems to be most frequent in the north and east, as it is common in Flint, Denbigh, Merioneth, and Montgomery (Forrest). Cardigan (Phillips, *Zoologist*, 1885, 258; Salter, *Journ. cit.*, 1903, 104), Radnor, and Glamorgan (Rope) may possibly be classed with the last four, as the records, although definite and undoubted, do not seem to be indicative of careful search. In Brecon and Carmarthen it is found very sparingly, especially in the latter (Phillips, *op. cit.*). In North Pembroke it has been taken by Bowen at Velindrè, Nevern, as I am informed independently by Mills and M. J. Lewis.

In the **north of England** it is generally but very thinly distributed in Yorkshire (Roebuck, *Field*, 5th April 1884, 488, corroborated by more recent observers). Approaching the northern limit of its range the records are meagre, and in Durham it reaches its most northern known habitat in England, as recorded by Mennell and Perkins in 1864. They wrote of it as of rare occurrence, but taken occasionally in the valley of the Derwent at Gibside, Winlaton Mill, and near Ebchester. More recently a pair were observed at Headlam, between Darlington and Barnard Castle in the south of the county (Rope). For Northumberland there is no record, but the localities cited above for Durham lie so close to the county boundary that the mouse may possibly be found within its limits. In Lancashire the Dormouse is distributed locally in the west and north, Macpherson's correspondents having met with it spasmodically in a few of the more densely planted districts from the Rusland Valley to the slopes of the fells at the southern end of Windermere; and similar information was supplied by Petty (*Naturalist*, 1889, 52). In 1861 it was not infrequent near Kendal, but Macpherson was unable to trace it to the east either of Westmorland or Cumberland. In the latter county it is found chiefly in the south, and was first recorded from the Ullswater district by Heysham, and later by Hodgson. Both Hodgson and Johnson took it at Dalston, near Carlisle, about 1880 (Macpherson). Dalston is of especial interest, because it yields to Winlaton Mills, Durham, by a few miles only in respect of being the most northerly situation in England where the Dormouse has been noticed.

The only **islands** in which the Dormouse is known are Anglesey (Forrest) and the Isle of Wight.

Since it has been found within a few miles of the Borders, there seems no reason why it should not occur in **Scotland**. But, although there are a few old records, *e.g.*, for Gifford, East Lothian (MacGillivray); Careston, Forfar (*New Statist. Account, Forfarshire*, 523); and for Scotland without locality (Walker; Fleming), Alston was unsuccessful in obtaining confirmation of them, and modern Scottish naturalists are unable to give the animal a place in their fauna.

The Dormouse is quite unknown in **Ireland**. Barrington set six free at Fassaroe, Co. Wicklow, on 13th November 1885 (*Zoologist*, 1885, 479), but, as he informs me, they were never heard of again. The season of introduction was not very well timed, since the animals would probably, in a state of nature, have already commenced hibernation.

[Jonston, *Historia Animalium*, 1650-53, i., 163-64, mentions its absence from Ireland, and its inability to live elsewhere in houses built of Irish oak. Rutty (1772) brands Jonston's statement as a "vulgar error," but though he rightly describes the animal's colour, he confuses its nest with that of the Harvest Mouse, and his statement that it occurs in Ireland shows that he could not have been himself acquainted with it.]

Distribution in time:—This species is not known as a fossil in Britain.

Origin:—The absence of the Dormouse from Scotland, as well as from the hiemally coldest part of the eastern plain of England, suggests at first sight that winter cold is the governing factor in its British distribution. But that is not the case, for in the greater part of its continental range it is subjected to winter temperatures lower than any experienced in the British Isles. Since the eastern plain is the driest part of England, humidity is also ruled out. The summer temperatures may next be considered. That of Norfolk in July, is about 62° F. that of the south-east of Ireland about 60° F., but since the extreme northern limits of the animal's range, both in Britain and Sweden, lie somewhere near the July isotherms of 60° F. and 59° F., deficiency of summer heat cannot have caused the absence of dormice from East Anglia and Ireland. Further, since the next coldest July isotherm, that of 58° F., passes through Scotland some distance north of that of 59° F., the gradient between the two being shallow, it would seem quite possible that there are a number of localities suitable for dormice in the south of Scotland, where the hazel is abundant; so that climatic conditions can hardly have caused the animal's entire absence from that country, in which it might be expected to occur locally.

It seems probable that the animal has been prevented by some barriers from reaching Ireland, Scotland, and the east of England. Its distribution, identity with continental *Muscardinus*, and absence from pleistocene deposits suggest a quite recent arrival in the south of England after the separation of Ireland; and it does not seem to have had time to enter Scotland or to cross rivers, fens, and marshes such as still cut it off from Norfolk (where it thrives well when introduced) and Suffolk. There the river Stour, with the marshes from Nayland to its mouth, appears to have been an absolute barrier to it (Laver, *MS.*), and possibly the Tyne and its tributary, the Derwent, may have exercised a similar influence in Durham and Northumberland.

Description:—The form, skull, and general characteristics of *M. muscardinus* are those of its genus. It is a short, compact, yellowish mouse, with rather large head, raised forehead, and long whiskers; eyes bright and very prominent; ears with a ridge above the meatus, rather short, and broadly rounded; nose rather blunt; tail reaching about six-sevenths of the head and body length, thickly and evenly haired without being bushy.

The hands and feet are rather short (Plate XXII.); the thumbs rudimentary; the first toes short and clawless. The remaining digits are long with well-developed terminal pads and strong short claws; they are not very unequal in length, the fingers graduating from third to fourth, fifth to second, and the toes from fourth, third, second to fifth. There are in each hand and foot six remarkably large and swollen, but not abnormally placed pads; there being the usual four lying at the bases of the digits, including a specially large one for each rudimentary thumb and short first toe; behind the latter are a pair of large long proximal pads, of which the outer plantar is particularly elongated.

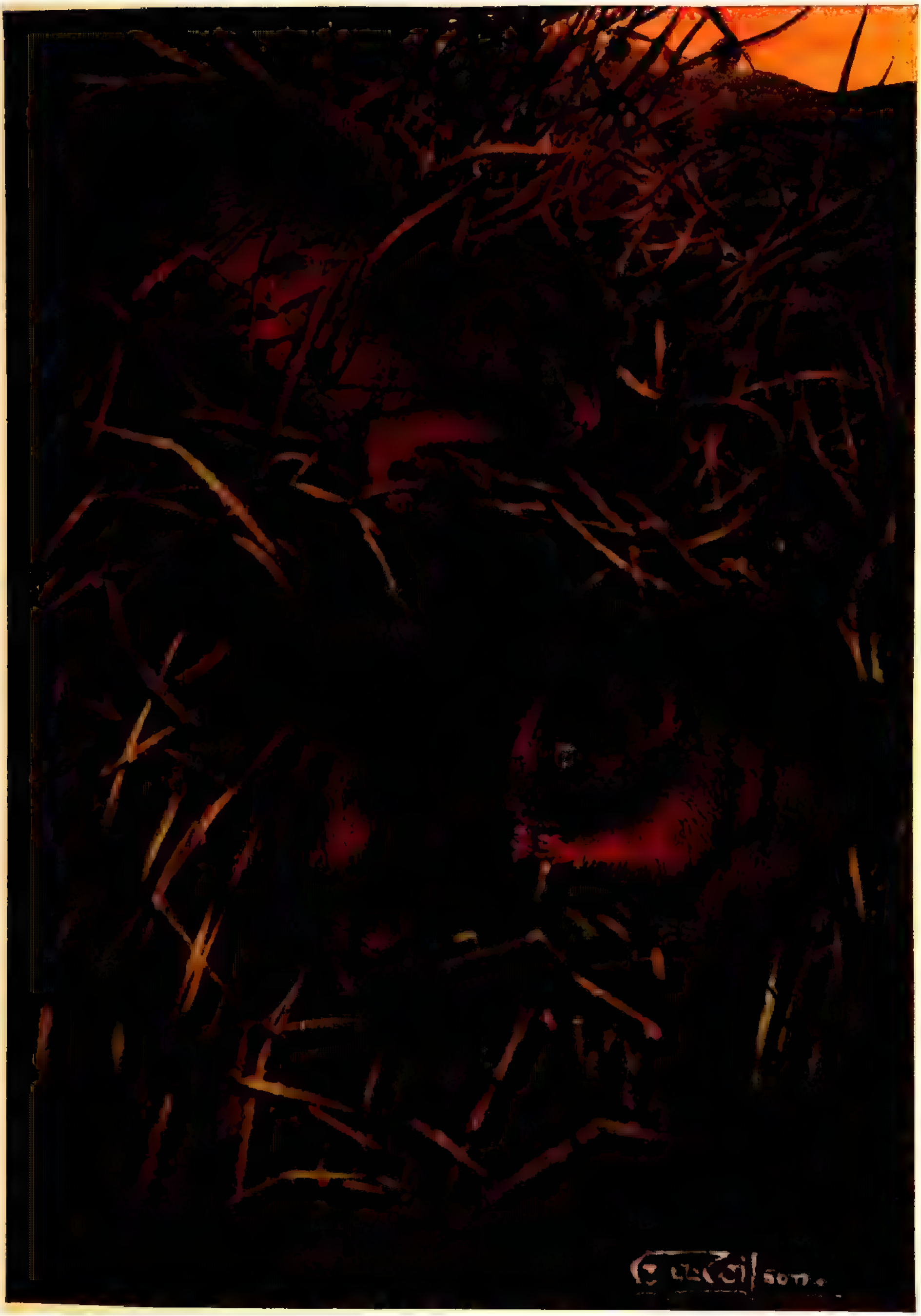
The colour of the upper side and of the anal region is brownish yellow. The tints are deepest and richest on the back (where there are some blackish hairs) and on the tail; paler on the flanks, which fade to cream or yellowish white on the under side; purer on the breast and upper neck, so as to form a whitish patch of variable size. The line of demarcation is indistinct, and passes along the cheeks slightly above the upper lip to just below each eye, thence along the flanks, leaving the internal surfaces of the limbs coloured like the belly, the external surfaces like the back. The tail is like the back above, slightly lighter below.

Nothing is known of the **moults**. The first coat of the young, which appears dorsally on the ninth day, is mouse-grey, lacking the yellower tints of the adult except on the head or fore parts of the body; it is cast (judging from Lataste's remarks) on or about the fifteenth or sixteenth day, when a pelage closely resembling that of the adult but with a less bushy tail is assumed; but the young are distinguishable until the spring following their birth (Bell, *ipse*), the adults being darker and more richly coloured.

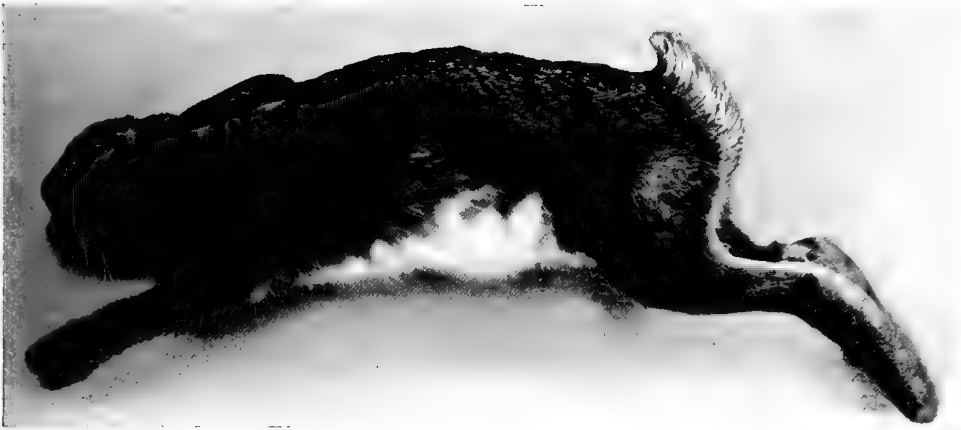
In the maxillary **teeth** the premolar has normally two ridges; these are joined internally and sometimes also externally, so as to form a raised circular rim. A small third ridge may be present at the back of the tooth. The 1st molar is about twice the size of the 2nd; it is decidedly longer than broad, and narrower in front than behind; its anterior border is oblique, its inner border abruptly notched behind the first of five very distinct outstanding ridges; these (except the last) slope obliquely backwards to the inner margin, and terminate exteriorly in five low cusps, which decrease in height regularly from front to back; interiorly the first ridge alone is cusped. The three anterior ridges are more widely separated than the two posterior; the first is isolated, but the remainder meet to form a longitudinal ridge on the inner border of the tooth. The 2nd molar is only slightly longer than broad, so that its outline is nearly square; it has seven low, nearly transverse, equidistant ridges, of which the outer extremities appear as five or six low cusps; all the ridges except occasionally the third, extend right across the tooth; the posterior ones may be branched. The 3rd molar resembles the 2nd, but is smaller, and its rounded posterior border is contracted; the posterior ridges are usually incomplete and confused.

In the mandibular teeth the lower incisors have roots extending distinctly beyond those of the 3rd molars. The cheek-teeth resemble those of the upper jaw; but the molars show less diversity amongst themselves, each having six distinct more or less transverse ridges, the terminations of which appear as low cusps. They diminish in size from before backwards, the third being little more than half the size of the first in crown area. The first is longer than broad, and narrower in front than behind; the second is almost rectangular in outline, but rather narrower behind than in front, and slightly longer than broad; the third is much constricted posteriorly.

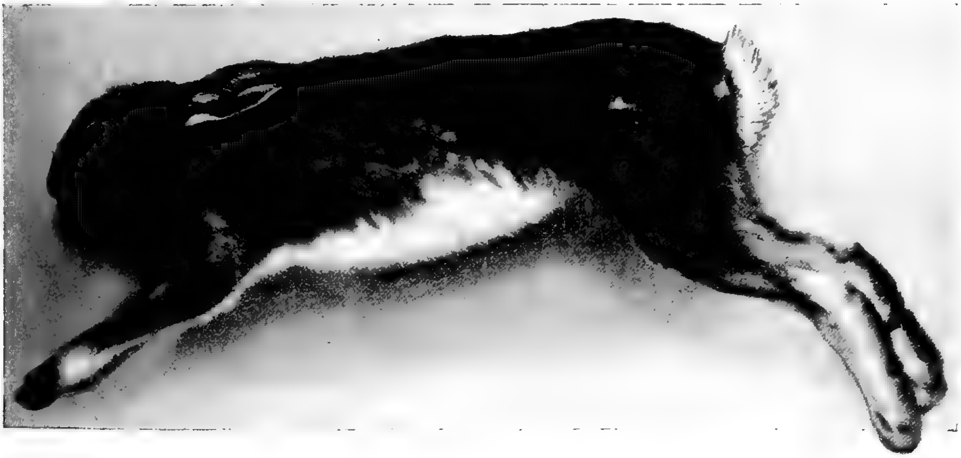
Individual variation is not conspicuous, but specimens with the tail tipped with white are frequently met with (as mentioned by Brookes in 1763); they are sometimes known as "lion dormice" (Adams), and are valued above the ordinary (see Rope, *Zoologist*, 1885, 212; Willmore *Journ. et ann. cit.*, 304; Parrott, *Journ. cit.*, 1887, 463). White or albinic varieties are very rare; the following may be mentioned:—one from Devon in Leach's collection (Bellamy); one, pure white, in the Borrer collection (Harting, *Field*, 17th March 1906, 433); one, wholly white with red eyes, taken alive in Kent (R. L., *Field*, 10th March 1906, 389); a pure albino from Guestling, Hastings, in the Hastings Museum; one, cream-coloured, in Whitaker's collection; three, white, in a litter of six half-grown young seen with normal mother by Owen Jones (*Field*, 22nd September 1906, 540; *Gamekeeper's Notebook*, 208).



South Orkney Grass Mice.



(1)



(2)

(1) BROWN HARE, subadult female, Poynetts, Buckinghamshire; (2) IRISH HARE, adult male, Kilmanock, Co. Wexford; to show differences in external appearance. (See pp. 337-338.)

Geographical variation:—As shown by the Italian and Sicilian forms, *pulcher* and *speciosus*, there is evidently a tendency to brighter tints and more striking contrasts in the south. In 1900 (see *Synonymy*), I separated the British form from *M. a. avellanarius* on the ground that, whereas each is more dully coloured than *M. pulcher*, the British, which I named *M. a. anglicus*, appears to have the upper side more brilliant, a whiter breast, and a thicker and shorter tail than the typical form. Miller, working more recently, is unable to accept this conclusion; but there is room for further study, as no series of British dormice is available for examination.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
MALES:—				
1. Purchased in London, 15th December 1898 (W. Dodson)	71	..	16	13
2. Honiton, Devon, 22nd August 1904 (G. C. Shortridge)	75	68	18	13
FEMALES:—				
1. Wendon Lofts, Saffron Walden, Essex, 31st May 1894	85	61	15	..
2. Colchester, Essex (G. S. Miller) . .	77	55	16	11
3 and 4. Purchased in London, 15th December 1898 (W. Dodson) . .	73	62	16	12
	70	55	17	12
SEX UNCERTAIN:—				
1. (No. 99.11.27.6 of British Museum Coll.), Bedford Purlieus, Thornhaugh, Northamptonshire, 5th January 1895 (H. H. Slater); type of *M. avellanarius anglicus* . .	86	57	16	..

Skull:—Greatest length, 22·7 to 24·5; condylo-basal length, 21·8 to 23; breadth at zygomata, 13·2 to 14·4; inter-orbital breadth, 3·0 to 3·4; mastoid breadth, 11; depth of brain-case at middle, 8·0; greatest length of nasals, 6·8 to 7·2; of diastema, 6 to 6·2; of mandible, 13 to 14; of maxillary tooth-row, 4·8; of mandibular tooth-row, 4·2 to 4·4.

Weight in grammes:—Rabus (*Zool. Garten*, 1881, 321-325, translated in *Zoologist*, 1882, 161-164) found that this varies between 23 and 43. It increases during the season of activity, especially in September, and attains its maximum just before the commencement of hibernation. It then decreases,[1] a female having dropped from 37 to 26 during hibernation lasting from 19th October to 27th March, or about at the rate of 2 a month. The September increment amounted in various seasons and individuals to from 39 to 43, 25 to 35, 24 to 37, 29 to 37, and 21 to 28.

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[1] Some naturalists have curiously supposed that both fat and weight increase during hibernation.

Distinguishing characters:—The peculiar colour and the pattern of the teeth are absolute distinctions amongst British mammals.

The Common Dormouse is a timid animal of gentle disposition. Although capable of extreme activity when frightened, it is naturally of a somewhat sluggish temperament, wearing an air of lethargy until roused, and sleeping away half the year in the more or less complete torpidity of hibernation. It has thus come to be regarded as a type of drowsiness. Shakespeare makes Fabian say—"to awake your dormouse valour";[1] and in our own day it figures in Lewis Carroll's *Alice in Wonderland.*

It is most at home near the edges of dense coppices and thickets,[2] in the undergrowth of which it builds its nest; and it is in creeping about in such surroundings that it exhibits its greatest adroitness, an adroitness quite unequalled by the agile Harvest Mouse, and scarcely surpassed by the Squirrel. It does not seem to have many enemies, but Mr E. G. B. Meade-Waldo informs me that it is preyed upon by owls.[3]

It is popularly supposed to feed chiefly on hazel nuts, and its technical name, *avellanarius*,[4] is based on this belief. But it eats also wild fruits and berries,[5] acorns, seeds, grain, and certain leaves.[6]

In eating a hazel nut it removes about one-third of the complete shell, but it cannot tell in advance if the kernel is sound, so that its boring operations are often abortive. In captivity it has been known to return to an empty shell and open a second hole.[1] With Barcelona nuts it gnaws through the edge of the rough circular patch and then downwards.[2] It often drinks largely, bending its head towards the water until its lips are immersed.[3]

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[1] *Twelfth Night*, iii., 2.

[2] Oxley Grabham has sent me a note of a remarkable habitat in Yorkshire—a plantation in the middle of a moor.

[3] The first specimen of *Dyromys milleri* (Thomas, *Ann. and Mag. Nat. Hist.*, April 1912, 394-395), a small dormouse of Central Asia, was picked up by J. H. Miller after having been dropped by a crow.

[4] From Abella, now Avella, a town in Campania, Italy, abounding in nuts, hence *Abellana nux*=the filbert. Some writers suppose that dormice are unable to open ripe hazel nuts, and in this respect experiences are contradictory.

[5] Especially of the mountain ash, when coming to eat which it may be snared with nooses (A. E. Brehm).

[6] In captivity it likes plums, apples, strawberries, and particularly cherries; in fact, all except very acid fruits, together with salad, Indian corn, almonds and nuts, but usually refuses meat, cheese, bread and milk, or eggs (Fernand Lataste, "Recherches du Zooéthique sur les Mammifères de l'ordre des Rongeurs," *Act. Soc. Linn., Bordeaux*, xl., 1887; L. E. Adams, *MS.*); lettuce, sorrel, and groundsel (Mayne Reid, *The Naturalist in Siluria*, 1889, 102).

It seems to be fond of sweet things, for more than one observer has found it devouring the "sugar" placed on a tree-trunk to attract moths,[4] and Mr E. Bidwell[5] saw one nibbling the flowers of honeysuckle to get at the nectar.

It will also consume aphides, nut-weevils, and caterpillars, and occasionally the eggs[6] of small birds; but, perhaps on account of its smaller size, it does not appear to be so much addicted to a diet of flesh or eggs as are the larger dormice of continental Europe. Retribution may sometimes overtake it when trespassing, for Mr A. H. Cocks once found one pecked to death in a thrush's nest.

Like many other rodents this mouse commonly sits on its haunches when eating, holding its food in its hands. But it will also suspend itself head downwards by means of its small but remarkably strong claws, and even feeds comfortably in that position; it can run up and down the naked bole[7] of a tree with astonishing rapidity. It is, besides, an active leaper, and springs from twig to twig for surprising distances.

The adults are almost entirely nocturnal, and rarely stir abroad until darkness is complete, but the young are both more careless and more active, and may be encountered by daylight. Comparatively few people, however, happen on one thus adventuring, and, as a rule, the first introduction to it is more or less of a surprise. The bird's-nester finds a round structure, about three inches in diameter, resembling a wren's nest, and on his touching it there rushes out a brightly coloured mouse, which slips with amazing activity through the underwood, or finally disappears from view on the ground. The intruder may, perhaps, have chanced to find a colony of nests, from each of which an inmate issues, and in the ensuing confusion it is quite likely that the whole party will make good their escape. On the other hand, if a single individual be pursued, it is one of the easiest of wild animals to catch, since, although extremely active, it has no certain retreat at hand, and its conspicuous coloration is not a help to concealment. When captured, it is inoffensive, and very rarely attempts to bite.

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[1] Reid, *op. cit.*, 99.

[2] Adams, *MS.*

[3] H. E. Forrest, *MS.;* Robert Kerr, *Animal Kingdom*, i., 270, 1792, thought that when thirsty they "dip their fore feet, with the toes bent, into the water, and drink from them!"

[4] H. Laver; R. Newstead, *Proc. Chester Soc. Nat. Sci.*, 1894, 248; J. R. B. Masefield, *MS.*

[5] *Field*, 16th July 1898, 134.

[6] It is sometimes found asleep on the broken or sucked eggs, but, as in the case of the Hedgehog, damage to eggs is not always intended, and C. E. Wright found one occupying a starling's nest in a hole in an oak, the eggs intact.

[7] Cocks, *MS.*

When several summer nests are found in association, they are near, but not touching each other, and rarely contain more than one inhabitant, so that the Dormouse may be described as gregarious, but not entirely sociable. Many nests are without opening of any kind, although with the wall thinner at the top where the inmate is accustomed to pass in and out; others possess a distinct circular opening, especially when empty, which opening is an unusual feature so far as British mice are concerned. They are usually placed amongst brambles or blackthorn, in hedges, or even in the tops of large tufts of grass,[1] and not often at any considerable height from the ground. But where some bird's nest can be utilised, the general objection to height seems to be waived, whether for purposes of sleeping, breeding, or hibernation, and in Sussex Mr Cocks found a mouse occupying a nest, apparently of a magpie, 20 feet up in a spruce fir. More frequently an old nest of blackbird, thrush, or wood-pigeon forms a platform. Holes in trees[2] are much appreciated when available, and the artificial nesting-boxes of bird-lovers are often selected.[3] At other times more lowly and unexpected situations are selected; in June 1903 two nests were found[4] at Warnham Pond, Sussex, in a very open situation in a bed of withies, standing in reeds and water. A furze bush often affords a convenient site, and in the Isle of Wight ivy-clothed rocks or trees, and ricks,[1] are much sought after; in other localities, the vicinity of the climbing "old man's beard,"[2] the downy seeds of which make a warm lining in autumn, or a dormitory may be formed entirely of them;[3] which shows how loosely these structures are held together. But the more usual materials are dried grass, gathered green,[4] and moss, lined with finer grass, or with warmer materials, such as sheep's wool. In Shropshire, Mr Forrest[5] has examined scores of nests all thus simply constructed. But near Shrewsbury the same writer[6] finds them never far removed from a clump of honeysuckle in autumn, when alone the dead bark can be obtained in quantity. This often provides the only material, long coarse strips externally, holding a lining of shreds; occasionally dead leaves are added, but no grass. Mr Cocks found one which, although autumnal (22nd Sept. 1903), was entirely composed of fresh green hazel leaves. The loose weaving of the nests, and the fact observed[7] in captivity that one can be put together in a single night, make it possible that several may be built by each individual in a season.

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[1] J. Steele Elliott (*MS.*), who finds many within 2 feet of the ground.

[2] At East Grinstead, Sussex, a pair were dislodged from a woodpecker's hole; F. H. Birley, *Zoologist*, 1887, 69.

[3] When these contain a nest from which young birds have flown, it is pulled to pieces, and leaves and other materials are added (Meade-Waldo, *MS.*).

[4] J. G. Millais.

For her young the female usually prepares a special nursery. This resembles, in its materials and construction, the ordinary summer dormitory, but is larger, the diameter being about 6 inches or more;[8] it is often placed close to, although not actually on, the ground; and careless mothers may even use an ordinary dormitory for a nursery. The separate retreat of the old male is generally not far away.

Dormice are sedentary, and probably monogamous creatures; being active only during the six months of plenty, and laying up a store against their spring awakening, they have no need to wander. Mr Steele Elliott watched two pairs for years, and their nests were always placed within 100 yards of a previous one. Mr Forrest has observed[1] the method of building in a captive. Seizing each piece of grass by the middle in its mouth, it dived into the nest-box, and, turning over repeatedly, laid the bent round the cavity, at the same time smoothing it and rounding it outwards.

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[1] Capt. Henry Hadfield, in G. T. Rope, *Zoologist*, 1885, 202.

[2] *Clematis vitalba.*

[3] Adams, *MS.*

[4] A common arrangement includes four layers, *e.g.*—(1) externally a few dead leaves; (2) grass; (3) a double layer of bramble leaves; (4) a lining of fine grass.

[5] *Zoologist*, 1901, 69.

[6] *Journ. cit.*, 1902, 23.

[7] Forrest; Lataste.

[8] Adams, *MS.*

It is generally stated that there are most frequently four young, but since there are eight teats, larger numbers may be expected. A litter of seven, still blind, was found on 8th October 1912 in Mr Cocks's wood at Skirmett, Buckinghamshire,[2] and others of six[3] and five[4] have been reported; sometimes there are only two young, and probably the earlier litters are smaller than those of the late summer.

There is some dispute about the sexual season. One view is that, like hedgehogs, dormice are polyœstrous (as they certainly are in captivity), with two breeding seasons, a litter of young being born early in the summer, followed by a second in the autumn. Thus Thomas Bell[5] received, from one locality in September, an adult, one about half-grown, and three very young, which he judged to be not older than a fortnight or three weeks. Messrs Cocks and Forrest have voiced another view, namely, that autumnal litters are the rule. In this they are partially supported by Monsieur H. Gadeau de Kerville, who states that in Normandy births take place habitually in August, with, perhaps, in favourable seasons, a first litter in June. Against this, Monsieur Lataste received a Swiss female which bore young on 1st June 1882, and there are British records for various dates from the middle of May[6] to October; so that it is possible that the breeding season may last throughout the period of activity. In captivity, when

[1] *Zoologist*, 1901.

[2] *MS.;* the eyes had opened by 13th October.

[3] Half-grown, near Basingstoke, Hampshire, September 1906 (Owen Jones, *Field*, 22nd September 1906, 540).

[4] In nest, Shropshire, 15th September 1903 (Forrest, *MS.*).

[5] Ed. 2, 284.

[6] Wright (*MS.*, per Adams) found a litter supposed to be two or three weeks old on 2nd June 1909, *i.e.*, born 12th to 19th May, and a Northamptonshire nest containing two young on 5th June; as their eyes were open on the 11th they must have been born, according to Lataste's observations quoted below, about eighteen days earlier, or on the 24th of May. In the Forest of Guines, Pas de Calais, France, Oldfield Thomas took five blind and naked young on 20th May 1894; see Barrett-Hamilton, *Proc. Zool. Soc.* (London), 6th February 1900, 86. A midsummer instance for young with closed eyes is 26th July (Heatley Noble, *in lit.*).

the onset of hibernation is postponed, litters may be born in the winter.[1] Monsieur Lataste concludes that the period of gestation is about three weeks,[2] and since captives will pair about every ten days, and the young are independent of their mother by about the twenty-fourth day, there is plenty of time for a series of litters between May and November. To produce young in the middle of May the mice must have paired shortly after concluding their hibernation.

The young at birth have the eyes and ears closed, and are destitute of hair. One born in the cages of Monsieur Lataste, opened its eyes on about the eighteenth[3] day, and on the nineteenth moved out of the nest for the first time and began to eat. When twenty-one days old, it attained the characteristic aspect of its race. It now began to climb about its cage; on the twenty-fourth day it differed from its parents chiefly in its lesser size.

If disturbed, the female, like other mammals, will sometimes remove her young by the scruff of the neck in her mouth, and Mr Grabham has photographed one in the act; such removals are, however, believed to be of rare occurrence.

By the end of September the Dormouse becomes exceedingly fat.[4] In October or November, having built its winter or hibernating nest, and laid up a store of food either beside or in its bed, each animal retires separately, and curling itself up into a ball, with its fore paws against its cheeks and its tail wrapped round its head and back, passes into torpidity.

The winter nest is usually constructed of moss, under an accumulation of leaves, it may be 2 feet thick, and placed in a hollow of the ground protected by roots of trees or stones. It may occupy a cavity in a tree-stump, sound or rotten, but frequently lies underground.[5] Quite often the hibernaculum differs neither in structure nor situation from a summer dormitory, and the torpid mice may also be found in bird-boxes, and in deserted nests of birds;[1] Mr F. W. Frohawk knew of one in mid-winter placed in an exposed alder bush. No doubt such rashness or remissness in providing for hibernation is severely punished in frosty weather.

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[1] Three young soon after Christmas, in captivity (L. A. Dunnage, *Field*, 4th February 1905, 190; see also *Field*, 8th November 1873, 485).

[2] *Op. cit.*; he states that in *Eliomys* gestation lasts twenty-two days, and œstrum recurs about every ten days.

[3] A very late date compared with a rabbit or mouse (see above, p. 211), perhaps because eyesight might lead to premature attempts to leave the nest.

[4] See above, p. 361, under *weight*.

[5] As deep as 2 feet (Frances Pitt, *MS.*). In 1904 Millais saw forty discovered amongst the fibrous roots of rhododendrons at Warnham Court, Sussex.

Hibernation is profound. The animal ceases to breathe,[2] and becomes so cold and rigid that it can be rolled like a ball across a table.[3] A mild day may call it back into transient life,[4] and it will then seize the opportunity to enjoy a meal[5] before again relapsing into slumber. But, with interruptions, its sleep lasts[6] until some day in April. By the latter month it has lost much of its fat, and it then completely awakes and enters upon the habits usual to an active state of being.

A hibernating dormouse can always be aroused, and its complete awakening requires about twenty minutes. When again left alone, however, it soon relapses into lethargy; but sometimes the disturbance to its system is fatal, especially if the change be too rapid, as when heat is too suddenly applied to it. During the few days just before and after hibernation, it is in a constant state of transformation from complete torpidity[7] to the most lively activity; and if kept warm in captivity this uncertain state can be much prolonged even in winter. But whenever it falls asleep, even in summer, its temperature drops and it feels cold to the touch. Mr Forrest[8] found the temperature of summer somnolence only 80° F., as against 98° F.[9] during activity.

The fate of the last litter of young is an interesting point in the animal's economy; newly born litters may be found

[1] Meade-Waldo, *MS.*; Millais.

[2] As observed by Lazare Spallanzani in 1807 (ii., 216-221 and 222-236) for this species and others.

[3] Douglas English, *Some Smaller British Mammals*, undated, 78.

[4] 5th December, dormice active (Steele Elliott, *Journ. Birmingham Nat. Hist. and Phil. Soc.*, 1896—unpaged reprint); any found in an active state during winter are instances of spasmodic awakening.

[5] Hence it may defecate during hibernation (Adams).

[6] One slept continuously for six months and twenty-three days; another, with one interruption only, for six months and nineteen days (Rabus, *op. cit. supra*, p. 361).

[7] Gordon Dalgliesh took one "in a complete state of torpor" (*Zoologist*, 1907, 299-300) on 9th May 1907.

[8] *MS.*

[9] 92°-94° F.—R. I. Pocock, *Encyc. Brit.*, 11th ed., art. "Hibernation," 442.

until the first week of November.[1] These would require their mother's attention so long as possibly to delay her own hibernation; hence it has been thought[2] that the members of these late broods always perish. The young certainly become lethargic more tardily than adults, and in captivity they often seem to be unable to put up fat, and may die in an emaciated condition without attempting to hibernate.[3] They must find the conditions of life harder than the earlier litters, but Mr Steele Elliott has kept them successfully through the winter.

Hibernation is more rigidly fixed in the routine of life in dormice than in hedgehogs. The influence of temperature[4] is shown, however, by their greater activity when kept warm in confinement, so that cold is evidently a predisposing cause, a stimulus which, as it were, starts the process.[5] It may not be more than this, since the corresponding condition known as "æstivation" manifests itself in the Tenrec[6] of Madagascar under precisely opposite conditions, namely, in the hot season.

The processes concerned are evidently very complicated and incapable of explanation under any single heading. It is quite likely that in many mammals the accumulation of fat,[1] which in temperate and arctic climates is usual in autumn, causes a progressive decrease of metabolic activity, and that the advent of a certain degree of cold, which is no doubt fairly definite for each species, consummates the matter by bringing the vital processes almost to a standstill. Add to this the effect of long custom regulating by inheritance the exact time or conditions under which the machinery shall slow down, and we seem nearer to a satisfactory explanation. But the actual process is in life influenced by questions of food and of individual differences. Thus, while dormice seem to have acquired such similarity of constitution that all the individuals may be said to become "ripe" for hibernation at about the same time, the same process in hedgehogs is spread over a much longer period, and the "ripening" is reached in a much more uncertain manner. The difference is probably connected with the more abundant food and the greater hardiness of hedgehogs; it also indicates a higher degree of specialisation in dormice. Both animals agree in that hibernation, having been once properly started, runs a more or less normal course until the body, having absorbed the fat by which its vital processes have been clogged, is stimulated to fresh activity by the warmth of spring, a warmth coincident with a renewed food-supply.

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[1] Newly born young, Bridgnorth, Shropshire, second week of October (Pitt, *MS.*); one ready to leave the nest, Skirmett, Buckinghamshire, 25th November, hence born say on the 4th (Cocks, *MS.*).

[2] As in the British Museum *Guide to the British Vertebrates*, 1910, 5.

[3] R. F. Tomes, in Bell, ed. 2, 284. In one case a member of a spring brood became torpid six weeks later than an adult.

[4] Marshall Hall, art. "Hibernation" in Todd's *Cyc. Anat. and Phys.*, 1839, 764-776; see also Pocock, *op. cit.;* and bibliography in *Phil. Trans. Roy. Soc.*, London, 1832. In 1792 a Mr Gough informed William Bingley that two captive dormice became inactive whenever the thermometer dropped to 42° F., resuming their activity at 47° F. Gough's figures are probably too high, since the average minimum, *i.e.* nocturnal, temperature of April, the month of awakening, varies between 37·3° on the 1st and 40·3° on the 30th. The corresponding temperatures occur in the autumn between the 4th (40·3°) and 15th November (37·4°). For these figures, compiled from the records for the sixty-five years 1841 to 1905 at Greenwich, I am indebted to W. W. Bryant, of the Royal Observatory. They must be taken as applying only roughly to other districts, and of course vary considerably from year to year. In 1793 Gough fed another dormouse well from April throughout the succeeding summer and winter, with the result that, although without artificial heat, it remained in good health and high condition, and during that winter never slept for more than forty-eight hours consecutively, and that but seldom; it was also active in the winter of 1794-5.

[5] As Karl Semper puts it (*Animal Life*, 1906, 111), by reduction below the optimum, which optimum may, in different animals, be high or low.

[6] *Centetes ecaudatus.*

Bats exhibit two forms of hibernation. Some species, such as Leisler's Bat, are highly specialised and experience a regular and normally continuous torpidity, and probably in these the process has been so ingrained by inherited habit that the stimulus of temperature and fat accumulation are hardly needed. In other species, such as the Pipistrelle, hibernation is intermittent, and here temperature would seem to be the sole stimulus—the temperature at which the food-supply disappears. In this respect the Pipistrelle is less specialised than bats which hibernate more regularly.

Hibernation may, therefore, be of two kinds—continuous, as in the Dormouse; intermittent, as in the Pipistrelle. It does not preserve the animal from cold, since it will die if not sheltered by a warm nest[1] or otherwise protected; it is rather a means of slowing the vital processes and utilising over-accumulation of fat during the season when food is harder to obtain. Hence it is caused by questions of food-supply rather than of temperature, although temperature must not be left out of account.

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[1] As suggested for *Glis* by Aug. Forel, who likened hibernation to catalepsy and hypnotic sleep (*Révue de l'hypnotism*, translated in *Zoologist*, 1887, 281); and by W. L. Hahn (see above, Vol. I., 29) for bats. Thin animals certainly cannot hibernate successfully.

The varying behaviour of a species under different conditions is shown by its habits on mountains, where the altitude determines the nature and date of hibernation. A North American Rock-Squirrel[2] hibernates only at high altitudes, and in the Marmots[3] of the Yakh-su Valley, Bokhara, the annual routine varies as follows:—At a height of 6000 feet they do not appear at the entrance of their subterranean abodes after the middle of August. Two thousand feet higher their feed is green much longer, and there they do not retire before the beginning of September. At 10,000 feet the cold alone sends them to sleep, because the water trickling from the snow keeps little kitchen-gardens growing for them.

Few animals are better suited than the Dormouse for the cages of those who love pets. Although it can on occasions be frightened into biting, as stated above, it rarely resents being handled or loses its temper, and it may become so tame as to recognise its owner and respond to a call.[4] It readily produces young in confinement. Like other small rodents, under the unnatural conditions of captivity it occasionally gnaws away portions of its own[5] or of a comrade's tail, and may even become cannibalistic.[6] The two last tendencies may indicate the absence of something necessary to its comfort, and Monsieur Lataste attributes[7] the death of captives during hibernation to loss of moisture by evaporation in a dry atmosphere.

Both when wild or in captivity this is a particularly silent animal. It emits, however, when frightened, a slight hissing,[1] described also as a "querulous cry,"[2] or, when expressing anger, a violent piping sound.[3] A "low whistling" is attributed to it by Mr Richard Kearton,[4] who has heard woodmen call it the "Singing Mouse."

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[1] After the severe winter of 1860-61 Laver found many dead in their nests in Essex. Yet they survive much severer winters in continental Europe, where they probably hibernate earlier or make their winter-nests more carefully.

[2] *Citellus;* see E. A. Mearns, *Bull. U.S. Nat. Mus.*, 1907, No. 56, 317.

[3] W. R. Rickmers, *Geographical Journal*, 1899, 604-605.

[4] J. A. Willmore, *Zoologist*, 1885, 304. For a good account of a captive dormouse by Hadfield, see *Journ. cit.*, 1862, 8025; 1863, 8481.

[5] Lataste, *op. cit.*, 42-43.

[6] For a female killing and eating a portion of a male confined with her in a roomy cage, see C. A. A. Dighton, *Nature Notes*, 1899, 75.

[7] An observation which, as he points out, applies generally to small vertebrates, as bats, reptiles, and, even more so, to batrachians.

Gough's specimen mentioned above must have survived for about four years in captivity, as also did one kept by Capt. Hadfield.[5] This period exceeds anything in the experience of the authorities of the Zoological Gardens,[6] where seventeen individuals had an average longevity of only three and a half, and a maximum of only thirteen months.

There are not many superstitions connected with this animal, although the older writers of pharmacies held some remarkable views in regard to its efficacy as a constituent in prescriptions. The majority, if not all, of these notions were based upon foreign beliefs applied to foreign species. Topsel, for instance, whose work is usually such a fertile hunting-ground for those in search of quaint information, does not appear to have known the British Dormouse, and Mr Millais quotes the German writer, Dr F. Helm,[7] without, however, noticing that he wrote of the Garden Dormouse of continental Europe.

[The "Button-Mouse" of Orkney, reported to Baikkie and Heddle (15, footnote) as being only 2 ins. long and "frequently found asleep rolled up in the shape of a ball," was thought by Forsyth Major (*Zool. Garten*, May 1905, 129-138), though on slight evidence, to be possibly a "Birkenmaus" of the genus *Sicista* (Gray, 1827, antedating *Sminthus*, Nathusius, 1839). This genus ranges from Central Asia to Denmark and South-eastern Norway, where the species is *S. trizona* of Petényi. It belongs to the family *Zapodidæ*, and is characterised by external murine appearance, but has 4 + 4 upper cheek-teeth, the crowns with two rows of tubercles arranged longitudinally.]

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[1] Lataste, *op. cit.*, 44. [2] Mayne Reid, *op. cit.*, 104. [3] Rabus, *op. cit.*

[4] *The Fairyland of Living Things*, 1907, 83. [5] *Fide* Rope, *op. cit.*, 1885, 213.

[6] See P. Chalmers Mitchell "On Longevity and Relative Viability in Mammals and Birds," in *Proc. Zool. Soc.*, London, June 1911, 447. This Dormouse is not mentioned in Max Schmidt's paper "On the Duration of Life of the Animals in the Zoological Garden at Frankfort-on-the-Main," in *Proc. cit.*, 20th April 1880, 299-319.

[7] *Zool. Garten*, 1887, 217-219, translated in *Zoologist*, 1888, 14-16.

MURIDÆ.

MICE AND RATS.

These are small rodents of varied habits and world-wide **distribution**. They date from the lower Eocene of North America and the lower Oligocene of Europe.

They have the thumbs rudimentary, the clavicles well developed, the tibiæ and fibulæ united. The **skull** has contracted frontal bones without post-orbital processes; slender zygomatic arches in which the short jugal bones are generally reduced to splints between the long zygomatic processes of the maxillæ and squamosals; the lower roots of the former processes more or less flattened into perpendicular plates; and the infra-orbital foramina tall and wide above, narrow below.

The **dental formula** is usually given as :—

$$i\,\frac{1-1}{1-1},\quad c\,\frac{0}{0},\quad pm\,\frac{0}{0},\quad m\,\frac{3-3}{3-3}=16\,;$$

this covers all, except a few Oriental forms, in which the posterior cheek-teeth disappear; but Forsyth Major (*Atti. Soc. Ital. Sci. Nat.*, xv., 1872, 111) considered that in the *Microtinæ* the anterior cheek-teeth are persistent milk-molars.

The **cheek-teeth** are superficially very diverse in structure. They may be high- or low-crowned, rooted or rootless, with prismatic or tubercular crowns of various degrees of complexity. All, however, may be traced to a common origin, a primitive, short-crowned, rooted organ with a highly complicated tubercular grinding surface. Even in the most highly specialised *Microtinæ* the young unworn cheek-teeth bear for a short time a tubercular enamel cap suggestive of their ancestry; and a tubercular tooth may wear down with use to a prismatic arrangement.

The food varies from grass to flesh, though no species[1] is entirely carnivorous; hence the *Muridæ* are almost ubiquitous, often occur in great numbers, and have probably caused more injury to man than any other mammals. Their destructive power caused them to attain importance in mythological systems of different parts of the world from the earliest times, as traced by Fraser in *The Golden Bough* (pt. v., vol. ii., 1912). In certain favourable seasons, recurring irregularly or in an unknown cycle, their numbers multiply exceedingly, and thus exert an extraordinary influence on other mammals and birds to which they are an indispensable prey, especially in sub-arctic regions (see Cabot, *In Northern Labrador*, 1912, App., 287-292; Thompson Seton, *The Arctic Prairies*, 1912, 107); in these years of increase they are specially disastrous to agriculture, but "mouse-plagues" are fortunately not frequent in Britain. Sometimes, as in the well-known case of the lemmings, the superfluous population may attempt to "migrate" to new districts, but rarely, if ever, with success. "Mouse-years" are, perhaps, caused by unusual abundance of food, and are characterised by exceptional fertility, in which the predatory creatures temporarily participate. Fertility decreases in the succeeding years of scarcity; frequently also disease appears, until the animals concerned almost vanish temporarily.

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[1] All British mice and rats are at times cannibals, *Epimys norvegicus* and *Evotomys glareolus* being probably the most guilty.

Swimming:—Although several British species swim well, they always use all four legs like a dog, none having acquired a more specialised method of propulsion (Adams).

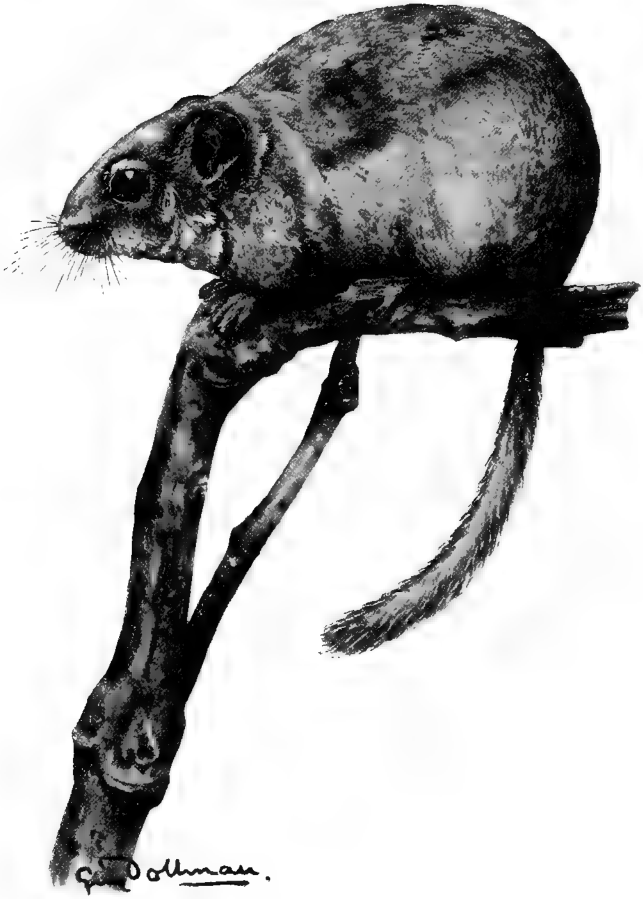
Pairing habits:—As usual in mammals, sexual maturity is attained before full size. In the females the urethra opens separately through a prominent clitoris. The vagina is closed in immature individuals, so that identification of the sexes is difficult in the young, the only guide being the shorter distance from clitoris to anus than from penis to anus. After sexual maturity the open orifice of the vagina makes identification easy. The mature male, if in good condition, is almost always capable of pairing; but in the females, although there is a long polyœstrous sexual season, "heat" lasts for a few hours only, at intervals which, in the absence of impregnation, recur about every eleven days. After effective pairing the vagina is closed, as in bats (see above, vol. i., p. 231), by a vaginal stopper, which remains in position for from twelve to twenty-eight hours, and is then expelled. This is a joint production, but chiefly of the male, which provides the major and central portion, consisting of a spontaneously coagulating material. The cortical portion supplied by the female is composed of detached epidermical cells. Gestation lasts normally thirteen to twenty-two days; but if the female is already rearing a litter, the development of the embryos may be suspended, their birth being postponed for another ten to fourteen (total, twenty-three to thirty-six) days. Pairing may take place very shortly after parturition. Lactation lasts roughly until the eyes of the young open, that is, about eleven days. The young of all British species are born naked, with a pink skin, blind, and with closed ears, but grow with much rapidity. If disturbed suddenly in the nursery the mother rushes out with her babies attached to her teats, but they soon drop off, and, if allowed to do so, she will carry them home in her mouth, her more usual method of handling them (see Lataste, Marshall, etc.).

Longevity:—Little is known on this point, and the general statement of Metchnikoff (*The Prolongation of Life*, 1907, 57), that the limit is five or six years, is probably not far from the truth. No member of the family has reached seven years in the London Zoological Society's Gardens (Mitchell).

History (including *Muscardinus*):—Accurate knowledge of the distinctions between the various species of rats and mice is of quite recent growth. The older naturalists seem to have confused shrews and mice, and Linnæus's genus *Mus* embraced twenty-two rodents now assigned to almost as many genera. Amongst British authors, Merrett in 1666 mentioned five species, only four of which are rodents: "the house Mouse," "a Rat," "a Water Rat," "the Erdshrew or Field Mouse," and "a Sleeper or Dormouse." Ray (1693) rightly separated the mice from the shrews, which latter he called *Mus araneus*; he added the Field Mouse. Seventy years later Pennant (1st ed., 1766) knew of only two additional species, the Norway Rat and the "Short-tailed Field Mouse." Correct technical names first appear in Berkenhout (1769), who used a single genus *Mus* for the above seven rodents, together with the Harvest Mouse which he added to the list. In Turton (1807) the Dormouse is transferred to the genus *Myoxus*, all the other species remaining in *Mus*, a classification which long prevailed, but in 1828 Fleming adopted the genus *Arvicola* for his Field and Water "Voles." No further change was made until in 1835 Jenyns, by the addition of the "Bank Campagnol," brought the list up to nine. Fleming's arrangement of genera also continued unaltered through the works of MacGillivray (1837) and Bell (1837 and 1874), until in 1895 Lydekker replaced *Myoxus* by *Muscardinus* and *Arvicola* by *Microtus;* he also admitted the Yellow-necked Mouse, bringing the number of species up to ten. Johnston (1903) adopted the genus *Evotomys* for the "Bank Vole"; he graded the Yellow-necked Mouse as one of five sub-species of his *Mus sylvaticus*, which, if all reckoned, make a total of thirteen. At this period the institution of sub-species and the preliminary difficulties of arranging them caused some instability. Millais (1905), retaining the same genera as Johnston, placed the Water Rat in the sub-genus *Arvicola;* his *Microtus orcadensis* raised the number of species to ten, in addition to which five sub-species of Field Mouse, two of House Mouse, three of Black Rat, with the Skomer and Sanday "Voles," both as sub-species, made a total of nineteen recognisable forms. No more recent work of authority has been published on British mammals, but in Miller's *Catalogue of the Mammals of Western Europe* (1912) there are eight genera, *Muscardinus*, *Evotomys*, *Microtus*, *Arvicola*, *Apodemus* (=*Mus sylvaticus*), *Micromys* (=*Mus minutus*), *Epimys* (=*Mus rattus* and *M. norvegicus*), and *Mus*, the latter now restricted to the House Mouse and its allies. Almost all the old species have now become genera, and, with the various recently discovered insular forms, they now reach nineteen, or, adding sub-species and admitting the Alexandrine Rat, a total of twenty-four recognisable forms. Some of the recent additions to the list are as distinct as any of the older forms, and are of considerable importance as representing survivals from an older fauna, and there can be no doubt about the interest of all of them. The present work in the main follows Miller's arrangement, but more recent study and ampler material has suggested alterations and one or two additions.

Pelage:—The general colour is derived from a mixture of the tips of at least two kinds of hairs. Of these the sparse longer are dusky; they represent the bristles of some foreign species. The abundant shorter hairs form the underfur; they

PLATE XXIV.



THE DORMOUSE.

are annulated, the basal and major portions being usually dusky. The first or juvenal coat of the **young** is distinct from that of adults, and precedes a post-juvenal coat of intermediate character. Two moults, one at each change of season, are probably normal, but their regularity is much interrupted by variable weather, the condition of the animals, and the influence of the long breeding season. The system of pigmentation and the principles of coat pattern are probably somewhat similar throughout the family, but having been chiefly studied in the House Mouse, are described under that species.

Droppings:—These are very distinct from the more or less rounded crotties of the *Leporidæ*, being elongated, thicker in the middle and tapering to blunt points at each end. Except in size, they are not distinctive as between the various species.

The British species fall into three **sub-families**:—the locally extinct *Cricetinæ*, or hamster-like rodents; the *Microtinæ*, or voles and lemmings; and the *Murinæ*, or true mice and rats.

A KEY TO BRITISH MURIDÆ,

WITH *MUSCARDINUS.*

I. EXTERNAL CHARACTERS:—

I. Size larger ("rats," with head and body not less than 175, hind foot not less than 30 mm.):—

1. Tail slightly more than half as long as head and body; ear 16 to 18 mm. . . *ARVICOLA.*
    - (A) Upper side brownish . . . *A. amphibius amphibius.*
    - (B) Upper side blackish . . . *A. amphibius reta* (Scotland, chiefly Highlands).
2. Tail about as long as, not longer than, head and body; ear 19 to 21 mm. . . *EPIMYS norvegicus.*
3. Tail longer than head and body; ear 24 to 25 mm.:—
    - (A) Upper side brownish . . . *E. rattus alexandrinus.*
    - (B) Upper side blackish . . . *E. rattus rattus.*

II. Size smaller ("mice," with head and body not exceeding 130, hind foot rarely reaching 27 mm.):—

- 1. Tail bushy, colour brownish-yellow . . *MUSCARDINUS avellanarius.*
- 2. Tail scaly or sparsely haired, not bushy:—
  - (A) Tail distinctly less than half as long as head and body . . . . *MICROTUS.*
    - (A) Size smaller (head and body averaging 100, hind foot 16-18 mm.), colour brighter (back in extreme cases rufous) *M. hirtus.*
    - (B) Size larger (head and body 110-125, hind foot 18-20 mm.:—
      - (A′) Colour brownish . . . *M. agrestis.*
        - (a) Upper parts with decided tinge of russet . . . *M. a. neglectus* (Scottish Highlands).
        - (b) Upper parts without tinge of russet:—
          - (a′) Under parts washed with wood brown (the hair-bases concealed); coat thick (hairs of back 13 mm.) . *M. a. exsul* (Hebrides).
          - (b′) Under parts dusky (the slaty hair-bases taking part in the general coloration); coat thin (hairs of back 8 mm.) *M. a. macgillivraii* (Islay).
      - (B′) Colour above rich brown, beneath buff . . . . *M. orcadensis* (South Orkney Islands).
      - (C′) Colour above greyish-brown, beneath buffy-grey . . *M. sandayensis.*
        - (a) Colour paler, back light "hair brown" . . . *M. s. sandayensis* (Sanday Island, Orkneys).
        - (b) Colour darker, back dark "hair brown" . . . *M. s. westræ* (Westray Island, Orkneys).
  - (B) Tail about half as long as head and body *EVOTOMYS.*
    - (A) Size smaller (head and body 90-100, hind foot 15·4-17 mm.), colour deeper *E. glareolus britannicus.*
    - (B) Size larger (head and body 100-110, hind foot 18-19 mm.), colour brighter . *E. skomerensis* (Skomer Island).
    - (C) Size as in *skomerensis*, colour as in *glareolus* . . . . *E. alstoni* (Mull).

(C) Tail about as long as head and body:—

(A) Size smaller (maximum of head and body about 75, of hind foot about 16 mm.) . . . . . *MICROMYS minutus.*

(B) Size larger (minimum of head and body about 75, of hind foot (rarely) 16 mm.):—

(A′) Hind foot 16-19 mm. . . *MUS.*

(a) Colour of under side markedly lighter than that of upper side, hind foot broader (4 mm.) . *M. muralis* (St Kilda).

(b) Colour of under side not markedly lighter than that of upper side, hind foot narrower (3-3·5 mm.) . . . . *Mus musculus.*

(B′) Hind foot 20-26·5 mm. . . *APODEMUS.*

(a) Size smaller (head and body about 95, hind foot about 22 mm.) . . . . *A. sylvaticus.*

(b) Size larger (head and body to about 126 mm., hind foot to about 26·5 mm.).

(a′) Under parts white:—

(α) With a collar-like chest-spot . . . *A. flavicollis wintoni.*

(β) Without a collar-like chest-spot . . . *A. fridariensis* (Fair Island).

(b′) Under parts more or less washed with buff or brown:—

(α) Under parts not so heavily washed . . . *A. hebridensis* (Outer Hebrides).

(β) Under parts heavily washed *A. hirtensis* (St Kilda).

II. TEETH AND SKULLS:—

I. Mandibular angle perforate; cheek-teeth 16 . *MUSCARDINUS avellanarius.*

II. Mandibular angle imperforate; cheek-teeth 12:—

1. Skull angular; cheek-teeth with prismatic crowns:—

(A) Palate simple, with shelf-like posterior edge; cheek-teeth rooted . . *EVOTOMYS.*

(A) m^3 with two internal infolds . . *E. glareolus.*

(B) m^3 with three internal infolds:—

(A′) Brain-case smooth and convex . *E. alstoni* (Mull).

(B′) Brain-case flattened . . *E. skomerensis* (Skomer Island).

(B) Palate complicated, with lateral pits; cheek-teeth rootless:—

(A) Size larger; "rats," with condylo-basal length rarely less than 39 mm.; m_1 with three closed triangles . . *ARVICOLA amphibius.**

(B) Size smaller; "mice," with condylo-basal length rarely reaching 30 mm.; m_1 with five closed triangles . . *MICROTUS.*

(A′) m^2 with four dentine-spaces:—

(a) m_1 with anterior loop nearly bilaterally indented:—

(a′) Cranium depressed . . *M. sandayensis westræ* (Westray Island, Orkneys).

(b′) Cranium not depressed . *M. orcadensis* (South Orkney Islands).

(b) m_1 with outer infold of anterior loop much less developed than inner infold . . . *M. sandayensis sandayensis* (Sanday Island, Orkneys).

(B′) m^2 with a small 3rd inner salient angle, making five dentine-spaces:—

(a) m^1 with three inner salient angles; bullæ small:—

(a′) Size smaller (condylo-basal length not exceeding 26 mm.) . *M. hirtus.*

(b′) Size larger (condylo-basal length reaching 28-29 mm.) . *M. a. neglectus* (Scottish Highlands).

(b) m^1 frequently with a small 4th inner salient angle; bullæ large:—

(a′) Temporal ridges anteriorly parallel in adults . . *M. a. macgillivraii* (Islay).

(b′) Temporal ridges anteriorly converging in adults . . *M. a. exsul* (Hebrides).

2. Skull rounded; cheek-teeth with tubercular crowns:—

(A) Rostrum short (distance from orbital constriction to anterior edge of nasals about $\frac{1}{3}$ total length of skull) . . . *MICROMYS minutus.*

(B) Rostrum normal (distance from orbital constriction to anterior edge of nasals about $\frac{1}{2}$ total length of skull):—

(A) Upper incisors notched; m^1 much longer than m^2 and m^3 together . *MUS.*

(A′) Mesopterygoid fossa sharply pointed anteriorly . . *M. muralis* (St Kilda).

(B′) Mesopterygoid fossa squarely truncate anteriorly . . . *M. musculus.*

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* The sub-species of *Arvicola amphibius* are omitted, as they do not possess diagnostic cranial or dental characters.

(B) Upper incisors not notched; m^1 about equal in length to m^2 and m^3 together :—

(A′) Size smaller; "mice" with condylo-basal length rarely exceeding 28 mm. . . . . *APODEMUS.*

(a) Skull comparatively massive and angular . . . *A. flavicollis.*

(b) Skull comparatively light and smooth :—

(a′) Size smaller (condylo-basal length not exceeding 24 mm.) *A. sylvaticus.*

(b′) Size larger (condylo-basal length not less than 24 mm.) :—

(α) Skull slender; coronoid process of mandible reduced . . . *A. fridariensis* (Fair Island).

(β) Skull normal; coronoid process of mandible not reduced :—

(α′) Size smaller (condylo-basal length 24-25 mm. *A. hebridensis* (Outer Hebrides).

(β′) Size larger (condylo-basal length 25·5-27 mm.) . *A. hirtensis* (St Kilda).

(B′) Size larger; "rats" with condylo-basal length rarely less than 38 mm. . . . . *EPIMYS.*

(a) Size smaller (condylo-basal length rarely reaching 45 mm.); cranium broader (external length of a parietal distinctly less than breadth of cranium between lateral ridges); m^1 without anterior cingulum, with distinct outer tubercle to first lamina . . . *E. rattus.*[*]

(b) Size larger (condylo-basal length rarely less than 45 mm.); cranium narrower (external length of a parietal about equal to breadth of cranium between lateral ridges); m^1 with anterior cingulum, without outer tubercle to first lamina . *E. norvegicus.*

[*] The sub-species of *Epimys rattus* are omitted, as they do not possess diagnostic cranial or dental characters.

[Sub-family *Cricetinæ*.[1]

HAMSTERS[2] AND WHITE-FOOTED MICE.

This large sub-family is specially characteristic of both Americas, where it almost certainly **originated,** but occurs also from Eastern China to Central Europe and in South Africa.

It is first known from the lower Eocene of North America (*Eumys*, Leidy, 1857). In the lower Oligocene (Quercy) of Europe it is represented by four species of *Cricetodon* (Schlosser, *Palæontographica*, xxxi., 1884, 96-97), some of which survived in Germany and France until the middle Miocene (see Forsyth Major, *Geol. Mag.*, August 1899, 372), but have not been identified from Britain. *Cricetus* (Leske, 1779) itself is found first in the middle Pliocene of Europe. One species, *C. runtonensis* (Newton, *Geol. Mag.*, March 1909, 110-12) occurs in the late English Pliocene of the West Runton Upper Freshwater Bed; it was slightly larger than the recent *C. cricetus*, and presents some dental peculiarities. Another,[3] of mouse-like size, from the Pleistocene of Hutton, Mendip Caves, Somerset, was referred by Sanford (*Quart.*

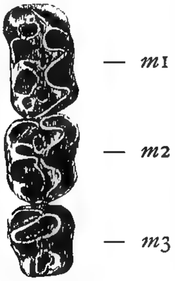

FIG. 52.—RIGHT UPPER CHEEK-TEETH OF *Cricetus runtonensis*, from the Pliocene of West Runton, Norfolk (crown view, magnified). From *Geol. Mag.*, March 1909, 111, by kind permission of Dr Henry Woodward and E. T. Newton.

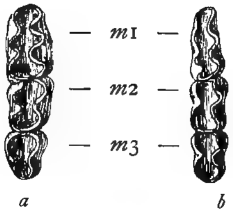

FIG. 53.—CHEEK-TEETH OF *Phodopus sanfordi*, from the Pleistocene of Hutton Cave, Somersetshire; *a*, left upper; *b*, right lower (crown view; six times life size; after Sanford).

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[1] Extinct in Britain.

[2] A German word of uncertain origin.

[3] Perhaps near Pomel's *C. musculus*, described (*Catalogue Méthodique*, 32, 1853) from Brèche de Coudes, Allier, Central France.

Journ. Geol. Soc., xxvi., 1870, 128, pl. viii., fig. 6; and *Proc. Somerset. Arch. and Nat. Hist. Soc.*, xv., 1868-69, 56, fig. 6, 1870) to *Mus songarus*, a form described by Pallas (*Reise*, 1773, ii., 703, pl. B., 1) from the river Irtisch, Siberia, but now placed in the genus *Phodopus* (Miller, *Smiths. Misc. Coll.*, 12th Jan. 1910, 498; Hollister, *Journ. cit.*, 29th Nov. 1912, 3). The Somerset specimens cannot, however, be synonymised with *P. sungorus*, and need a new name. They may be appropriately known as *Phodopus sanfordi*, and thus form an interesting addition to the British fauna. *Phodopus*, which is in external form and teeth less highly modified than *Cricetus*, is known also from the Altai District (*P. crepidatus* of Hollister), and North-eastern Mongolia (*P. campbelli* of Thomas).

The *Cricetinæ* are, like the pikas, of peculiar interest, being ancient generalised forms which have retained primitive characters, suggestive of the probable development of the more highly specialised *Microtinæ* and *Murinæ* from a cricetine-like ancestor. Their cheek-teeth are rooted, and, as in the *Murinæ*, the crowns are tubercled, but the arrangement in the upper jaw is one of two, not three, rows. As the tubercles wear down, a triangular, microtine-like pattern is revealed.

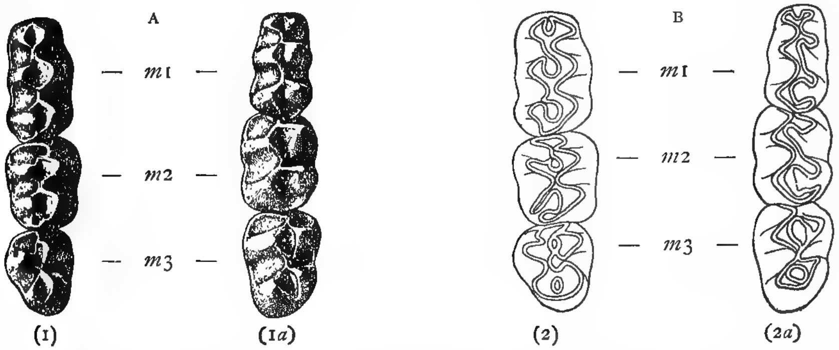

FIG. 54.—CHEEK-TEETH OF *Cricetus cricetus* (crown view; five times life size); A, unworn; B, slightly worn; 1, 1a, right upper; 2, 2a, left lower. From Miller's *Catalogue of the Mammals of Western Europe*. (By kind permission of the Trustees of the British Museum of Natural History.

The Cricetines, like many other groups represented in extra-arctic regions of both hemispheres, have no widespread form identical or representative in both. They are older than the existing land connections, and their present absence from Britain, the Ultima Thule of their wanderings, must be regarded as due solely to local causes, perhaps connected with the latest Glacial Period, or to the competition in large numbers of the more highly organised *Muridæ.* Having been exterminated in Western Europe, they were unable to return to Britain in time to reoccupy it. The absence of the Hamster, *Cricetus cricetus* (Linnæus),[1] from Skandinavia, Denmark, Britain, the Iberian Peninsula and Italy, marks the present stock as being recent immigrants to the rest of Europe; the immigration is perhaps still in progress, the species having much extended its range in France since 1870 (see *A travers le monde*, v., 41, 14th October 1899, 325-326).]

Sub-family *Microtinæ.*[2]

VOLES AND LEMMINGS.[3]

The **classification** of this sub-family is largely due to Miller, and is a natural system in contradiction to the artificial arrangements of most previous investigators—de Sélys, Blasius, Fatio, Baird, Coues, Blanford, and Lataste; for references to the works of whom, and for further technical details, see Miller's "Genera of Voles and Lemmings," being *North Amer. Fauna*, No. 12, 1898; also Hinton's "Preliminary Account of the British Fossil Voles and Lemmings," in *Proc. Geol. Assoc.*, 3rd June 1910, 489-507.

Characters:—These rodents are all burrowers, more or less completely adapted to an earthbound or even a subterranean existence, and therefore lacking the variety of shape and habits which is so prominent a feature of the *Cricetinæ* and *Murinæ.* Their eyes are usually small, and their external ears reduced in size.

In the **skeleton** the pubic symphysis is greatly shortened. In accordance with the diet of coarse and tough vegetable substances, the cheek-teeth and masticatory muscles are exceptionally powerful; the **skull** is massively constructed, and several of its paired bones, such as the maxillæ, palatines, and frontals, which usually remain free in other *Muridæ*, are fused together at an early stage in the existence of the individual (see Winge, *Vidensk. Med. Nat. For. Kjob.*, 1881, 37-50 (1882); *Grònlands Pattedyr*, 1902, 358; *Danmark's Pattedyr*, 51, 68-79).

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[1] The report of its naturalisation in South Ronaldshay, Orkneys, "having been brought there in a Norway vessel, which suffered shipwreck," was shown by John Wolley (*Zoologist*, 1849, 2344) to be an error, perhaps based on the known presence of *Epimys rattus.*

[2] *Arvicolinæ* of many older writers.

[3] "Lemming," from the Swedish and Norwegian, probably = "destroying."

The **cheek-teeth** are hypsodont and often endowed with the power of persistent growth. Their evolution, which is analogous to that of the pikas (see above, pp. 155-158), has been worked out by Hinton, to whom I am indebted for a *résumé* of his, at present unpublished, results. Although the actual ancestors of the *Microtinæ* have not yet been discovered, there can be no doubt that their cheek-teeth were of a brachyodont, tubercular type; the apical or first-formed and most conservative parts of these teeth in recent forms still retain such a structure, and in the more primitive genera, such as *Dicrostonyx*, remains of three longitudinal rows of tubercles are present in both upper and lower series when unworn, showing that the group has descended from a stock with murine rather than cricetine cheek-teeth. Such brachyodont teeth were adapted for crushing and grinding; they have gradually been converted into a most perfect apparatus for slicing and shearing. The first step in the process has been the atrophy, by fusion or blending, of some of the less useful primitive tubercles. The cusps have thus been arranged in an inner and outer alternating series of triangular form, the evolution of which can be readily appreciated by examining the changes in pattern shown by the molars of *Cricetinæ* in different stages of wear (Figs. 52 and 54).

The transition from a soft and succulent to a tough and dry diet has been gradual. It has been accompanied by steadily increasing wear of the crowns of the cheek-teeth, by increased nutrition of these organs, and by prolongation of their period of growth. Since during the earlier stages growth exceeds attrition, the cheek-teeth have become hypsodont; in later stages growth and wear are equal, and this condition persists until death in the higher genera of the group, as in *Microtus*; in lower forms, as *Evotomys*, a time comes when the enamel organs fail, and thereafter growth of the crowns ceases, the dentinal pulps gradually atrophy, and in so doing form two tapering roots—an anterior and a posterior—to each tooth.

During their progress towards hypsodonty and persistent growth the inner and outer triangular cusps have been converted into triangular prisms, the structure of which partially explains the final steps in evolution of the cheek-teeth of the higher *Microtinæ*. Each triangle is bounded before and behind by enamel (Fig. 57, *e*); with a thick internal lining of hard and dense dentine (*d*) and a central core of a softer, more highly vascular tissue, the osteo-dentine (*o*). Owing to its superior powers of resistance the enamel always stands out in relief upon the triturating surface of the teeth. In lower forms, as *Evotomys* (Fig. 63), the enamel is rather thick, and, as in primitive mammals generally, of uniform thickness at practically all points upon the margins of the teeth. In the higher forms, *i.e.* those like *Microtus* in which the power of subsisting upon a coarse and tough vegetable aliment reaches its highest expression, the cutting and slicing functions of the cheek-teeth are most completely developed, and in order to put them in operation the motion of the jaw becomes almost exclusively an antero-posterior one. In consequence of this, certain portions of the enamel become of diminished utility and tend to become thin; other portions, directly obstructing the antero-posterior motion of the jaw, atrophy and disappear. In most living *Microtinæ*, therefore, the enamel has become differentiated into thin and thick portions; the thick is usually found on the concave sides of the prisms, which are, in upper teeth, the posterior, in lower, the anterior; the thin enamel forms the convex sides; further, in the anterior or posterior "loops" of m_1 and m^3, and at the tips of the salient angles, the enamel is frequently lacking. As in other primitive mammals, the valleys or infolds were originally devoid of cement, and this condition is still met with in some genera which in many other ways seem to stand as high or higher than the majority of their allies, *e.g.*, in *Dicrostonyx* (Fig. 55) and *Ellobius*; in other genera cement is found partially or wholly filling the re-entrant folds or cement-spaces (Figs. 57, 63, etc.).

The reduction in the number of primitive elements characteristic of the ancestral cheek-teeth has not been limited to obliteration of one of the three longitudinal rows of tubercles, but, in addition, as insisted by Hinton, certain tubercles in the anterior and posterior portions of each tooth have undergone reduction, though to a very variable extent in the different genera. This phenomenon is the expression of a general law, subject in *Microtinæ*, so far as is known, to no exception; thus, even the cheek-teeth of *Dicrostonyx* and *Fiber*, the most complex known in the group, show, when unworn, ephemeral traces of further longitudinal complications which may have been inherited from a remote ancestor.

From a systematic point of view the enamel pattern of the cheek-teeth of *Microtinæ* is of great importance. Although abnormalities are found in 25 per cent. of individuals of some species, these are frequently appearances caused by different stages of wear. The pattern is, on the whole, remarkably characteristic and constant in each species or group of species, certain teeth, especially m^3 and m_1, being particularly diagnostic. The arrangement in the various species will be more easily understood by a reference to the teeth of *Dicrostonyx*, in which the pattern is seen in its longitudinally most complex and primitive form—a form from which all the other patterns may be derived by the reduction or fusion of one or more elements. For convenience sake the parts of each upper tooth are enumerated from before backwards, those of each lower tooth from behind forwards. The prisms are spoken of as "triangles" or "loops" according to their form in the crown view of the teeth. In every case where suitable material could be examined, Hinton finds that "loops" are combinations of two or more cusps.

In *Dicrostonyx* (Fig. 55) m^1 is composed of an anterior transverse loop, followed by six alternating triangles, the anterior internal; the postero-internal is somewhat reduced in size, the postero-external is vestigial; briefly described, this tooth has seven dentinal spaces, and presents on each side four salient angles separated from each other by three infolds. m^2 possesses a similar pattern, but is more reduced, having only two instead of three inner triangles following the anterior loop; the anterior is outer instead of inner, and as a whole, this tooth possesses six dentinal spaces, four outer salient angles with three infolds, and three inner salient angles with two infolds. In some species of *Dicrostonyx* (*D. torquatus* and the extinct British *D. gulielmi*) m^1 and m^2 have, in addition to the parts enumerated above, a minute vestigial postero-internal salient angle (Fig. 55, n^1)—the last trace of what may once have been an important element in each tooth. m^3 is essentially like m^2 in form, differing merely in the degree of reduction of its posterior portion; the first five dentinal spaces are like those of m^2; the fourth outer angle—the vestigial one in the anterior teeth—is here largely developed, as is also, on the inner side, the homologue of the minute postero-internal angles of m^1 and m^2 of *D. torquatus* and *gulielmi*; these two triangles are incompletely separated from each other by the third inner fold, and together they form a crescentic posterior loop; briefly, this tooth has six or seven dentinal spaces, with four salient angles and three infolds on each side.

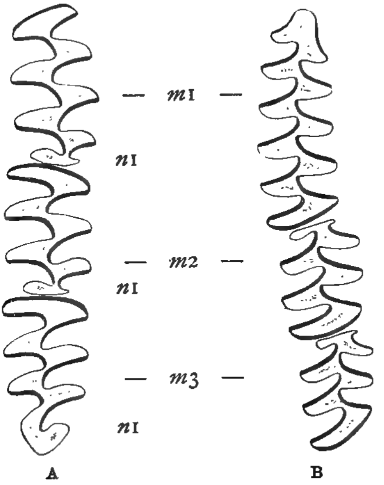

FIG. 55.—CROWN VIEW OF RIGHT UPPER (A) AND LOWER (B) CHEEK-TEETH OF *Dicrostonyx torquatus*. Drawn by M. A. C. Hinton (7½ times life size).

The lower cheek-teeth of *Dicrostonyx* (as also of other *Microtinæ*) are in general like those of the upper jaw, but the transverse loop is at the posterior instead of at the anterior end of each tooth (Fig. 55, B). m_1 consists of a posterior transverse loop, preceded by seven substantially closed triangles, of which four, including the anterior, are internal and three external; anterior of all is a loop of complex structure, into the composition of which some four or more originally distinct cusps enter; occasionally one or two of the posterior of these may be completely separated off from the more forward part of the loop by infolds in the usual manner, thus increasing the number of closed triangles to eight or nine; there are never fewer than nine dentinal spaces, five outer and six inner salient angles, and four outer and five inner infolds. The two posterior teeth, essentially like each other in form, are considerably simpler than m_1; each has a posterior transverse loop, preceded by four alternating triangles, exactly corresponding to the hinder part of m_1; in m_2, in front of the fourth triangle, and but partially shut off from it, is a vestigial pair of prisms of which the outer member is the more reduced; in m_3 the reduction of this vestigial pair is carried still further, and the fourth triangle itself is quite small. Each tooth has thus five dentinal spaces, three salient angles and two infolds on each side, and in addition is complicated by the presence of the vestigial structures described.

Dental formula:—Forsyth Major long ago argued that the dental formula of the cheek-teeth should be written as $dm\,\frac{1}{1}$, $m\,\frac{1-2}{1-2}$, the anterior cheek-teeth being regarded as persistent milk molars. This view has recently been revived by Hinton; it is based upon the extraordinary complexity of the anterior cheek-teeth and upon various theoretical considerations, and support is lent to it by an instance recorded by Winge of the occurrence of a small fourth posterior cheek-tooth in *M. agrestis*. In describing the teeth here the older notation is retained as being more convenient.

The sub-family is **circumpolar**. Reaching its main development in temperate climates, it ranges south to the northern coasts of the Mediterranean, northern India and Mexico, and north to the limits of mammalian life. It first appears in the Pliocene of Europe, but in America not before the Pleistocene, so it may have **originated** in the Old World.

It is closely related to the *Cricetinæ* and the American Wood Rats (*Neotominæ*), but is readily distinguished by its skull and teeth. Besides the *Ellobii*, which are unknown in our area, it includes two supergeneric groups, the *Lemmi* or lemmings, and the *Microti* or voles, the former extinct in Britain. It possesses great interest from the primitive characters by which it seems to be connected with the Malagasy *Brachytarsomys*, a genus which, so far as structure goes, might itself have been a forerunner of the *Microtinæ* (see Forsyth Major, *Proc. Zool. Soc.*, London, 1st June 1897, 719).

[GROUP LEMMI.

Lemmings are short-tailed microtines. Their external appearance as typified by *Lemmus* is described below. The **skull** is broad and massive; the lower incisors are short, their roots ending on the inner sides of the cheek-teeth, the crowns of which in the upper jaw are of about the same width from front to back.

The lemmings are a highly specialised modern group of a relatively low and decadent type, formerly of wider distribution, but now in course of replacement by more dominant genera. They reached their zenith in the late Pleistocene, the mammalian fauna of which indicates a climate supporting a plentiful vegetation. The bulk of this fauna is now extinct or the members widely dispersed, some to arctic regions, others to mountains, others to islands of mild climate —a combination showing that retreat from competition with the present entirely distinct fauna is the key to their present distribution. Far from being confined by choice to a polar environment, it is probable that the latest glacial period was injurious to the lemmings to the extent of partial extermination, and they would not now be restricted to polar regions did their foes permit them to exist elsewhere. They certainly, in their well-known "migrations," make many attempts to colonise new districts, and these are believed to be invariably failures, owing to the ease with which, in the absence of snow, they are captured by carnivorous enemies. They survive in apparently undesirable regions, because, like the varying hares, they have the power of thriving on coarse, innutritious food, and because, thanks to their small size, they are enabled to shelter themselves under the snow, and thus not only to escape being eaten, but to remain active throughout the winter.

NOTE.—The arguments for lemmings being essentially "arctic" animals have been given by Nehring in his *Tundren und Steppen* (1890, i., 60), and by Stejneger (*Amer. Nat.*, 1901, 101), relying on Merriam's "law" of the distribution of animals and plants in definite climatic life-zones (*National Geog. Mag.*, 29th December 1894, 229-238). The dependence of mammals, except in very special cases, primarily on food rather than on climate has been emphasised by me in the "Mammalia of the Clare Island Survey" (*Proc. R. Irish Acad.*, September 1912, No. 17, 9). All northern naturalists, *e.g.* Manniche for Greenland, agree about the helplessness of lemmings in the absence of moderately deep snow. In Novaya Zemlya their snow-tunnels are very remarkable, as described by Nordenskiöld (*Voyage Vega*, 1881, i., 146-7); in Alaska, in the absence of snow, their runs may be in moss, and they may have young in every month of the year (Buxton in Allen, *Bull. Amer. Mus. Nat. Hist.*, 31st March 1903, 152). For the ease with which lemmings may be dug out and killed by man or carnivora, see Buxton (*op. cit.*); Preble, *North Amer. Fauna*, No. 22, 1902, 56; and Goldwaite (in Bangs), *Proc. Biol. Soc.*, Washington, 17th September 1897, 237).]

[GENUS LEMMUS.[1]

The true lemmings are stout, short-legged, thickly furred animals, with disproportionately large heads, short but well-developed valveless external ears, and rudimentary tails. Both hands and feet are highly specialised for a fossorial existence, the palms and soles being large, broad, strong, and densely furred, and the pads absent or rudimentary; the digits, except the thumbs, are provided with long, sharp, but simple claws, not subject to periodic changes, and borne on greatly enlarged, unequal phalanges; the thumbs carry remarkably powerful nails.

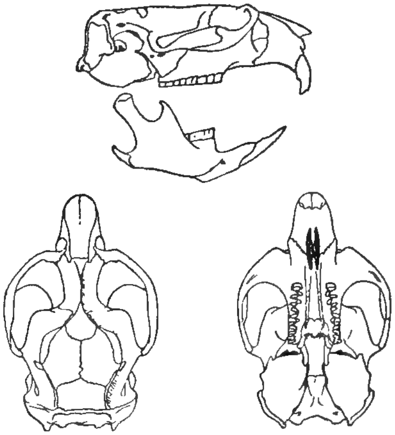

FIG. 56.—SKULL OF *Lemmus lemmus* (life size). From Miller's *Catalogue of the Mammals of Western Europe*. (By kind permission of the Trustees of the British Museum.)

The **skull** is particularly heavy and massive, with low, broad brain-case. The temporal ridges unite to form a knife-like ridge between the orbits. The short rostrum is thick and heavy. The auditory bullæ are large, and of spongy texture. The powerful zygomatic arches are expanded centrally into wide, strongly oblique plates; the anterior edges of the squamosals form narrow but distinct shelf-like post-orbital processes. The pterygoids are short, with the lateral pits of the bony palate deep, and the anterior edge of the inter-pterygoid fossa carried forward dorsally past the overhanging edge of the palate.

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[1] Extinct in Britain. *Lemmus*, Link, 1795, antedating *Myodes*, Pallas, 1811, is based on *Mus lemmus* of Linnæus.

In the **teeth** the ungrooved upper incisors are comparatively slender. The cheek-teeth (Fig. 57) are rootless; their tooth-rows converge anteriorly, their crowns are very broad, and the enamel-pattern is characterised by reduction of dentine-spaces, sharp enamel-angles, and deeply cut infolds; the latter run almost right across *m*1 and *m*2 on the outer upper and inner lower sides; in some cases they are opposed by salient angles presenting a peculiar appearance of square truncation.

Except where modified by the features just described, m^1 and m^2 do not differ from those of normal *Microtinæ.* m^3 is formed of four transverse loops; the first is isolated from the second by a deep outer fold; the second from the third by the approximation of an inner and outer fold, the former a little deeper; the third similarly from the fourth, but the inner fold is very deep, the outer a mere vestige.

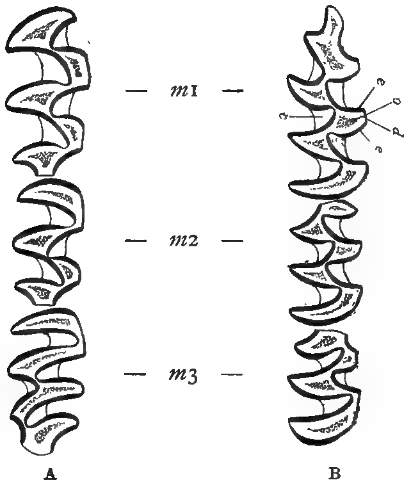
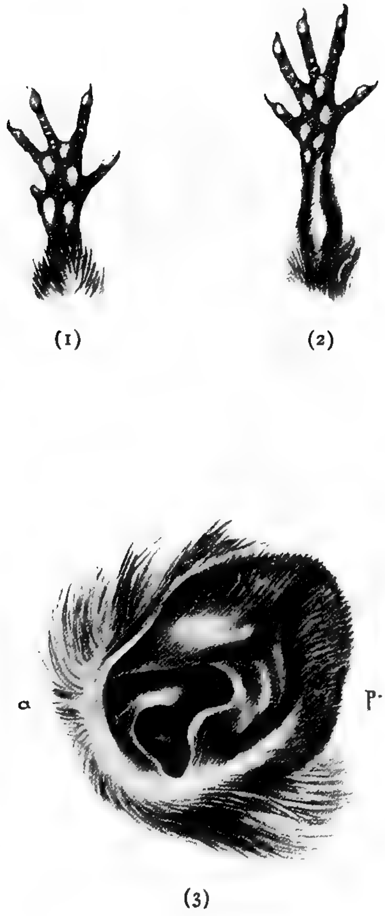


FIG. 57.—CROWN VIEWS OF RIGHT UPPER (A) AND LOWER (B) CHEEK-TEETH OF *Lemmus lemmus* (7½ times life size); from the late Pleistocene of England. (Drawn by M. A. C. Hinton.)

m_1 has the posterior loop preceded by three closed triangles, and an anterior loop formed by the blending of two or three reduced dentinal spaces; it presents three outer and four inner salient angles. m_2 agrees in structure with that of *Microtus*, and differs merely in having the two outer closed triangles relatively small. m_3 is essentially similar; its postero-internal fold is, however, deepened, so that it extends practically across the crown, and the antero-external triangle of m_2 is not represented; there is a large foramen below and behind the alveolus.

The above characters show extreme specialisation in skull and teeth, but in external characters *Lemmus* is not so specialised as *Dicrostonyx.*

PLATE XXV.



THE BANK MOUSE—*Evotomys glareolus.*

(1) LEFT HAND AND (2) LEFT FOOT (twice life size);
(3) LEFT EAR (3½ times life size).

Lemmus is now confined to circumpolar regions, mostly in arctic latitudes, including Novaya Zemlya (*L. obensis*), but not Spitzbergen, Franz Joseph Land, Iceland, or Greenland. In North America it ranges from Alaska to Hudson's Bay, north to about 70° N. lat. in Boothia Felix (Ross), and south to about 55° N. in the Peace River region (Preble); with an insular species, *L. nigripes* (True), in St George's Island, Bering Sea. *L. obensis* (Brants), of Arctic Siberia, has an isolated colony in the Syansk Mountains, west of Lake Baikal, at 2200 feet (Thomas).

L. lemmus (Linnæus),[1] the well-known Norwegian Lemming, extinct in Britain, is now confined to Skandinavia, south to Christiansand (Collett) and northern Wermland (Lilljeborg), with Finland and Russian Lapland to the Kola Peninsula.

It was widely distributed in the **Pleistocene** or post-Pleistocene of Western and Central Europe, its bones having been found in North Germany, Saxony, Poland, Hungary, Belgium, and Switzerland (Hensel, *Zeits. d. Deutsch. Geol. Gesellsch.*, Berlin, vii., 486, pl. xxv., figs. 10, 11, and 15, 1855; Nehring, *Zeits. f. Ges. Naturw.*, Berlin, xlv., 1-28, 1875). Gadow's discovery of "mummies" of a *Lemmus* (Barrett-Hamilton, *Proc. Zool. Soc.*, London, 3rd March 1896, 304), in caves near Athouguia, Santarem, Portugal, has been a stumbling-block to many, who refuse to accept the locality as correct (*e.g.*, Harlé, *Bull. Soc. Géol. de France*, 1909, 98; *Comm. da Commis. do Serv. Geol. de Portugal*, viii., 52, 81, 1910-1911). But Nehring (*Sitzungsb. der Gesellsch. naturf. Freunde*, 1899, 3, 55; also Wiegemann's *Archiv für Naturg.*, lxv. (i.), Bd. 2, 175-182) assigned them to a distinct variety named *crassidens*, on account of its large teeth, and Miller agrees that the Portuguese remains cannot at present be synonymised with *L. lemmus*. This fact supports the unexpected locality, but a collector sent by Hailé to examine all the caves in the neighbourhood failed to find further specimens.

In Great Britain it was first reported by Sanford (*op. cit. supra*, pp. 382-3) from Somerset caves, and it is now known to have been an abundant member of the late Pleistocene, and perhaps of the prehistoric fauna, having been identified also from Forest of Dean, Gloucestershire; Ightham, Kent; Langwith, Derbyshire; and Dog Holes, Warton Crag, Lancashire. It was probably present at Hoe Grange Quarry, Longcliffe, Derbyshire, as well as (with *Dicrostonyx*) in the earlier brick-earth of Erith, in the Thames Valley (see Newton, *Geol. Mag.*, October 1890, 455).[1]

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[1] *Mus lemmus*, Linnæus, *Systema Naturæ*, x., 59, described from the mountains of Lappmark, Sweden.

In Ireland it is known only from Doneraile Cave, Co. Cork, where it was discovered by Ussher in 1904 (*Journ. Cork Hist. and Arch. Soc.*, xvii., 92, 123; *Irish Naturalist*, 1904, 237 and 248, also 1910, 42), along with mammoth, bear, reindeer, wolf, and a large hare (true *Lepus*).

Some of its remains have such a fresh appearance that the animal may well have survived until prehistoric or historic times. Those from Portugal included the entire dried skins and ligaments of two complete individuals.

Hinton concludes that the lemmings, helped by their well-known migratory habits, reached Ireland, with the ancestor of the Irish Hare, during the latter part of the pleistocene period, at which time the land stood high enough to lay bare the bed of the North Sea to a latitude somewhere north of the Dogger Bank. The meagre Irish fauna shows that the connection between Ireland and England could only have been inconsiderable or temporary, probably between Carnarvonshire and Wicklow.

The absence of *L. lemmus* from Siberia, from the south-west and south of Sweden, and from the late glacial deposits of Denmark (Winge, *Vidensk. Meddel. Naturh. For.*, *Kjobenhavn*, 1904, 3, 223) caused Stejneger to suggest (*Smiths. Misc. Coll.*, 4th May 1907, 478), with much probability that, with the Varying Hare of Norway, it reached Skandinavia from Scotland by means of a land bridge across the North Sea.

No ancestral forms of *Lemmus* occur in Britain, whither it probably came from the East. Its absence from eastern North America and Greenland seems to indicate an Old World origin, and that its passage between the Old and New Worlds was by way of Bering Strait.

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[1] Hinton (*Proc. Geol. Ass.*, 3rd June 1910, 496) believes that remains from Uphill Cave, Weston-super-Mare, Somersetshire, represent a second species as yet undescribed.

The principal original references to the ossiferous caves or fissures mentioned in the articles on lemmings are as follows :—

Ightham Fissures, Valley of the Shode, Kent, Abbott and Newton, *Quart. Journ. Geol. Soc.*, 1st May 1894, 171-209; Newton, *Journ. cit.*, August 1899, 419-429. Wye Valley Cave, Forest of Dean, Gloucestershire, Bate, *Geol. Mag.*, March 1901, 101-106. Hoe Grange Quarry, Longcliffe, near Brassington, Derbyshire, Arnold-Bembrose and Newton, *Quart. Journ. Geol. Soc.*, 28th Feb. 1905, 43-64. Langwith Cave, Derbyshire, Mullins and others, *Journ. Derby Arch. and Nat. Hist. Soc.*, 1913. Dog Holes, Warton Crag, Lancashire, Jackson, *Lancashire Nat.*, Nov. 1909, 227-229; Feb. 1910, 323; March 1912, 420-422. Kesh caves, Co. Sligo, Ireland, Scharff, Coffey, Cole, Ussher and Praeger, *Trans. R. Irish. Acad.*, Sept. 1903, xxxii., B. iv., 171-214. See also Blackmore and Alston, *On Fossil Arvicolidæ*, *Proc. Zool. Soc.*, London, 16th June 1874, 460-471.]

[GENUS DICROSTONYX.[1]

The Banded or Arctic Lemmings are less specialised in dentition and skull than the true lemmings, but much more so in external characters, thus enabling them to exist in higher latitudes. Some, at least, of the species whiten in winter. The external ears are quite rudimentary. The hands undergo remarkable seasonal changes. The thumbs are very small, and their nails minute; the claws of the two middle digits in summer resemble those of *Lemmus*, but in winter they are greatly enlarged in conformity with the subterranean life of the animal at that season; after attaining a maximum, portions of them are shed somewhat like the horns of some ungulates; the claws of the second and fifth digits are large, but not peculiar in form. The hind feet, which carry several minute pads near the bases of the claws, are very broad, the proportions of length to breadth being about as two to one.

The **skull** resembles that of *Lemmus*, but is smaller and more lightly built, with zygomata less broadly bent and expanded, lighter and more slender rostrum, and pterygoids proportionately longer. The temporal ridges never unite, and there is consequently a noticeable longitudinal furrow in the inter-orbital region. The auditory bullæ are not enlarged or particularly spongy. The anterior edges of the squamosals give off very characteristic, peg-shaped, post-orbital processes.

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[1] Extinct in Britain. *Dicrostonyx*, Gloger, 1841, based probably on *Mus hudsonius* of Pallas, from Labrador, antedates *Cuniculus*, Coues, 1877, which latter is also preoccupied (see above, p. 172.)

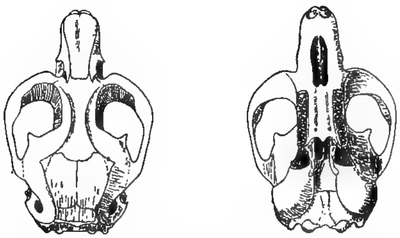

FIG. 58.—SKULL OF *Dicrostonyx* (life size). Drawn by M. A. C. Hinton.

The characteristic pattern of the **cheek-teeth** has been described on p. 388 (Fig. 55). The infolds on the opposite sides being about of equal depth, the dentine-spaces are of nearly equal size on each side. The tooth-rows are nearly parallel, and there is no noticeable foramen behind the alveolus of m_3.

Dicrostonyx is now confined to circumpolar regions, where *D. torquatus*[1] ranges from the eastern shores of the White Sea probably throughout arctic Siberia, and *D. hudsonius* (Pallas),[2] or other species, are found throughout the arctic regions of America and north through the islands of the Polar Sea, where they are sometimes innumerable, through Grinnell and Grant Lands to beyond 83° N. lat. on the north-west coast (Aldrich). In Greenland, *D. grœnlandicus* (Traill, Scoresby's *Journal Voyage Northern Whale Fishery*, 1823, 417) is found from the extreme northern point in about 83° N. along the entire coast, south-west to about 81° N. in Hall's Land, and south-east to 69° N. (Feilden MS.). Feilden (*Quart. Journ. Geol. Soc.*, 1878, 566) found its remains in post-pliocene beds of Grinnell Land, at an elevation of at least 300 feet above present sea-level, and hence argues that it is not a recent immigrant to Greenland. A southern species, *D. unalescensis* of Merriam, occurs at Unalaskah, in about 54° N. lat.

The genus is known as a fossil from France (Puy de Dôme, and Brèche de Coudes, Allier; described by Pomel as *Arvicola* [*Myolemmus*] *ambiguus*, *Ann. Sci. de l'Auvergne*, xxv., 1852, 363; first correctly identified by Hensel in 1855, later by Forsyth Major, *Atti. Soc. Ital. Sci. Nat.*, xv., 1872, 111, pl. 2);

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[1] *Mus torquatus*, Pallas, *Novæ Species Quad e Glirium*, 1779, ii., 205, described from the arctic regions of the river Obi, Siberia.

[2] *Op. cit.*, 1779, ii., 208, described from Labrador.

from Quedlinburg, Saxony (Hensel, *op. cit. supra*, p. 393); Eppelsheim, near Darmstadt, Hesse, Germany; and Hohlenstein, near Ulm, South Germany (Forsyth Major).

In England the genus makes its first appearance, with *Lemmus*, in the brick-earth of Erith, Thames Valley (Newton, *Geol. Mag.*, October 1890, 454), and is present also in later pleistocene deposits. It was extremely abundant, and occurred, as first pointed out by Forsyth Major (*op. cit.*, 123), as two cotemporary species now both extinct, *D. gulielmi* and *D. henseli.*

Of these, *D. gulielmi*[1] was described from specimens in the Taunton Museum, obtained in Wookey Hole Cave, Somerset. It is characterised by large size, short and broad incisive foramina, broad nasals, and heavy teeth, m^1 and m^2 having minute postero-internal salient angles. Hinton has identified it from Langwith Cave, Derbyshire (*Ann. and Mag. Nat. Hist.*, July 1910, 38; Forest of Dean Cave, Gloucestershire; Crayford and Erith brick-earth; Kesh caves, Co. Sligo, Ireland (where *Dicrostonyx* was very numerous in some strata), and from France.

The other species, *Dicrostonyx henseli* of Hinton (*op. cit.*, 37), described from a skull in the collection of Abbott, from Ightham Fissures, Kent, has also been identified from the Arctic Bed of Angel Road, Tottenham, Middlesex (Hinton, *Quart. Journ. Geol. Soc.*, June 1912, 249); Langwith Cave, Derbyshire; Doneraile Cave, Co. Cork (where *Dicrostonyx* occurred with *Lemmus* in enormous numbers, see Ussher, *op. cit. supra*, p. 394); as well as from Quedlinburg (Hensel's original skull of *ambiguus*, the dental peculiarities of which were noticed by its discoverer). This is a small species with reduced tooth-pattern, m^1 and m^2 lacking the minute postero-internal salient angles, and having the posterior wall of the postero-external triangle reduced; it thus resembles rather *D. hudsonius* of Labrador, but is smaller than that species; it has also less expanded nasals, the presphenoid bone is reduced to a mere rod, and the teeth are heavier.

Remains from the following localities have not been assigned to particular species:—Murston, near Sittingbourne, Kent (Newton); Fisherton River, near Salisbury (Blackmore and Alston); Dog Holes, Warton Crag, Lancashire (Jackson); Corstorphine, Edinburgh (mandible found by Bennie and identified by Newton—see *Scott. Nat.*, 1913, 97-100, where W. Evans mentions another Scottish find, to be recorded later by Horne and Peach); and the Irish caves of Co. Clare. As with the Norwegian Lemming, the bones are sometimes remarkably fresh, noticeably those from the Co. Clare caves.

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[1] *Arvicola gulielmi*, Sanford, *Quart. Journ. Geol. Soc.*, xxv., 1870, 125, pl. viii., figs. 4 and 4a.

The absence of *Dicrostonyx* from Skandinavia is remarkable in contrast to the almost entire restriction therein of *L. lemmus.* If *Lemmus* reached Skandinavia from the west, it is difficult to understand why *Dicrostonyx* failed to do so. It looks as if *Lemmus* had ousted the more specialised *Dicrostonyx* in Western Europe. The fact that *Dicrostonyx* was evidently unable to enter Skandinavia from the east or south, favours the truth of the suggestion of the western origin of *Lemmus* in Skandinavia.]

GROUP MICROTI.

VOLES OR VOLE-MICE.

The mice of this group are generally known in recent zoological works as "voles" or "vole-mice." Vole = "a field" is an abbreviation of "vole-mouse" = "field-mouse," a north English word used by Barry (1805) for the Orkney species (compare Norwegian "voll," Icelandic "voell-r"). The word is often incorrectly used, especially in such cases as "Field Vole" = "Field Field"! For this reason it is, perhaps, fortunate that it has not reached the general public, but is confined to zoological works. Its use ought to be restricted by naturalists, a course which may, perhaps, be best followed by retaining it for the group *Microti*, in which sense its application is convenient, and discarding it from the actual species.

The majority of voles may be distinguished at a glance from lemmings by their smaller head, more slender body, thicker fur, and longer ears and tail; the latter is (except in *Lagurus*) much longer than a hind foot, and thus intermediate between those of lemmings and true mice. In their more ordinary hands and feet the palms and soles are provided with pads. Voles are thus externally less specialised, but cannot be absolutely separated from the lemmings, since a few members of either group exhibit the characters of the other. The **fur** is usually soft, the **colours** rarely bright. The **skull** is comparatively slender and lightly built. In the **teeth** the lower incisors are long, and the extremities of their roots lie on the outer sides of their m_3; the cheek-teeth have the dentine-spaces subequal, and their upper crowns become distinctly narrower from front to back.

These are hardy animals, never hibernating, and continuing their activity in winter beneath the snow of boreal countries.

The group is of wide and almost ubiquitous distribution in the extra-tropical regions of the Northern Hemisphere, where a number of genera have been for the most part recently differentiated. There are several British species, which fall into three existing genera (*Evotomys*, *Microtus*, *Arvicola*); a single extinct genus (*Mimomys*); and a genus and sub-genus (*Pitymys* and *Chionomys*), extinct in Britain, but still existing in continental Europe.

GENUS EVOTOMYS.

1811. MYODES, P. S. Pallas, *Zoographia Rosso-Asiatica*, i., 173, based on *Mus lemmus* of Linnæus, hence antedated by LEMMUS, Link, 1795; de Sélys-Longchamps, *Études de Micromammalogie*, 1839, 87, section based on *Lemmus rubidus* of Baillon, 1834 = *Mus glareolus* of Schreber; Lataste, *Le Naturaliste*, 15th October 1883, 349, sub-genus based on *Mus rutilus* of Pallas = *Evotomys rutilus.*

1831. HYPUDÆUS, misprinted HYPUDACUS (col. 874) and HYPUDEUS, (pl. vii.), E. Mehlis, Oken's *Isis*, viii., based on *H. hercynicus* of Mehlis = *Mus glareolus* of Schreber; Keyserling and Blasius, *Die Wirbelthiere Europa's*, 1840, viii., and 34, sub-genus based on *Mus glareolus* of Schreber; preoccupied by HYPUDÆUS of Illiger, *Prodromus Syst. Mamm. et Avium*, 1811, 87; the latter based on *Mus lemmus* of Linnæus, hence antedated by LEMMUS, Link, 1795.

1874. EVOTOMYS, Elliott Coues, *Proc. Acad. Nat. Sci.* (Philadelphia), 186; genus based on *Mus rutilus* of Pallas.

1900. EUOTOMYS, Erwin Schultz, *Zeitschr. für Naturwiss.* (Stuttgart), 19th December, 203; Collett.

1900. CRASEOMYS, G. S. Miller, *Proc. Wash. Acad. Sci.*, ii., 87, a sub-genus of EVOTOMYS based on *Hypudæus rufocanus* of Sundevall; Thomas, *Proc. Zool. Soc.* (London), 1906, 863 (genus).

1902. EOTOMYS, C. J. Forsyth Major, *Proc. Zool. Soc.* (London), i., 107, a misprint.

1905. PHAULOMYS, Oldfield Thomas, *Ann. and Mag. Nat. Hist.*, May, 493; a sub-genus of EVOTOMYS based on *E. smithii* of Thomas.

Although but recently defined, the genus *Evotomys* has been universally accepted, and (neglecting Mehlis's misprint) there can be no doubt about its correct name. It includes a number of somewhat generalised and primitive species, presenting external characters, as in the proportions of the eyes, ears, and tail, somewhat intermediate between lemmings, voles, and true mice. The roots of the cheek-teeth recall the murines. The lower incisors pass each to the buccal side of its m_3, as in other *Microti*, but at a lower level, so that the latter tooth is not so markedly displaced. The tendency to adopt a rufous mantle arising from a dull or plumbeous juvenile pelage is a development on specialised and perhaps peculiar lines.

Although enjoying green food these mice are not restricted to the surface of the ground. They run more actively than *Microtus*, jump moderately well, but are unable to bound like *Apodemus*. They are fond of woods, where they climb trees, though not to great heights, devouring berries, fruits, and bark, and in cold countries amass stores of provisions. They may also eat invertebrates, and, when opportunity offers, young birds or small mammals. They swim well, and inhabit a variety of situations, from sandhills on the sea-coasts to mountains. In the north they may in winter occupy a position resembling that of the House Mouse of temperate regions.

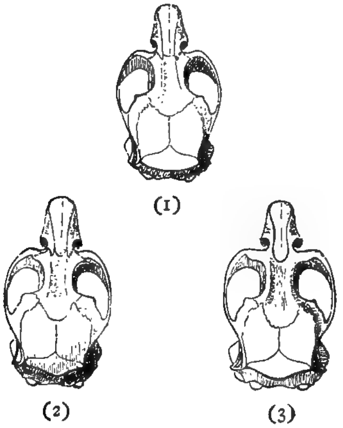

FIG. 59.—SKULLS OF BRITISH *Evotomys* from above—(1) *E. glareolus britannicus*, old, the cheek-teeth with long roots; (2) *E. alstoni*, old, the cheek-teeth with long roots; (3) *E. skomerensis*, adult, the cheek-teeth with short roots; natural size. (Drawn by M. A. C. Hinton.)

Characters:—With a few exceptions, they resemble typical *Microtinæ*, but are lighter, more elegantly built, and have the dorsal surface usually of some shade of rufous; deeper and richer in humid, wooded regions, lighter and yellower with a tendency to winter whitening in the north. The eyes and more or less circular ears tend to be more conspicuous than in *Microtus*; the feet are small, with normal pads; the tail is shorter than in murines, longer than in *Microtus*; the fur is long and soft in winter, shorter and harsher in summer. The **mammæ** are 8, viz., 4 inguinal and 4 pectoral.

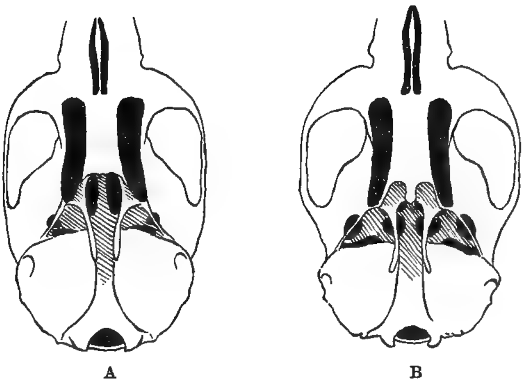

FIG. 60.—PALATE OF (A) *Evotomys*; (B) *Microtus* (diagrammatic and magnified).

The **skull** shows some murine characters, being comparatively weak, and lacking in angularity. The outlines are full and rounded, the ridges, even in old age, slightly developed. The interorbital region is broad, the auditory bullæ large and comparatively inflated. The zygomata are usually slender, and scarcely widened in the regions where the jugals and zygomatic processes of the maxillaries meet; the mandible is slender and weak. The bony palate lacks the sloping part of the posterior median ridge, and shows little trace of the lateral pits, both so characteristic of *Microtus*; it thus terminates in a thin-edged shelf continuous between the alveoli of the posterior cheek-teeth. This arrangement was at first thought to be highly characteristic, but has since been found in other genera, as *Anteliomys* and *Eothenomys*.

The incisors are weak and slender, and those of the mandible run back, each along the lingual sides of its first and second cheek-teeth, crossing the tooth-row behind the latter, and terminating in the ascending ramus of the mandible distinctly below the dental foramen; not rising above the level of the cutting surface of the cheek-teeth nor forming a protuberance on the outer surface of the mandible.

The cheek-teeth are small, narrow, weak, and, in the young, rootless. Their growth from a rootless to a rooted condition causes great changes in the enamel pattern, which gradually loses its definiteness, and finally disappears. In the young teeth the dentine-spaces extend to the base; at which a ring forms later, then contracts and divides into two, each half becoming a broad root as the tooth is pushed upwards. When immature the enamel is thin, the salient angles sharp, the infolds wide and shallow, and consequently the dentinal spaces confluent. When adult the enamel is thick, the tips of the salient angles rounded, and the infolds deeper. The elements of the teeth are crowded longitudinally, so that the alternation of the inner and outer triangles tends to be inconspicuous; further, the outer infolds of the lower teeth are usually shallow, so that each pair of prisms tends to form a transverse loop rather than an inner and an outer closed triangle. These features are characteristic of all the normal members of the genus. m^1 and m^2 are of normal form, having the anterior loop followed by four and three substantially closed triangles respectively; the outer triangles are in each tooth slightly larger than the inner. In m^3 the anterior loop precedes two outer and one inner prisms, followed by a posterior loop of variable shape; the inner prism is usually closed, but all three may be closed or open, leaving a continuous dentine area along the centre of the crown; the inner is usually the largest, the postero-external the smallest.

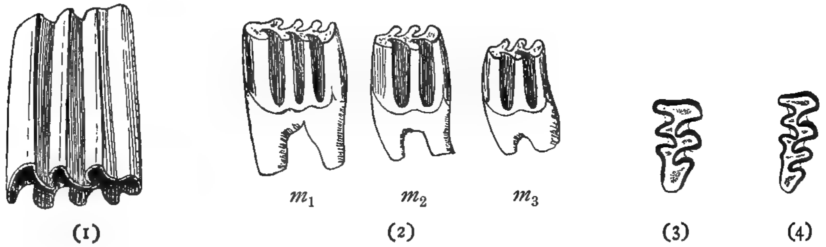

FIG. 61.—(1) ANTERIOR LEFT LOWER CHEEK-TOOTH OF *Arvicola amphibius*, tilted so as to show open pulp cavities. (2) LEFT LOWER CHEEK-TEETH OF *Evotomys glareolus*, both seen from outer side. (3) *E. glareolus*, simple form of m^3. (4) *E. skomerensis*, complex m^3. (Drawn by M. A. C. Hinton.)

The posterior loop may be simple or complicated by the presence of extra infolds — generally a shallow antero-external and a deep internal[1]—the latter extending across the tooth nearly to the enamel of the outer side; there are many intermediate conditions, but in the simplest form there are on each side three salient angles and two infolds; in the most complicated form there are four or five salient angles and four infolds on each side.

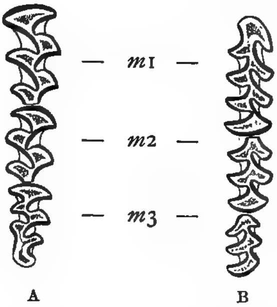

FIG. 62.—RIGHT CHEEK-TEETH OF *Evotomys glareolus* (A, upper; B, lower; crown view; 7 times life size).

In m_1 the posterior transverse loop is preceded by two outer and three inner more or less closed triangles; the tooth has thus four outer and four or five inner salient angles; the third inner triangle opens more or less broadly into the short anterior loop, which presents externally a well-marked salient angle, while its inner border may form another salient angle or may be rounded and only slightly salient.

m_2 and m_3 are composed each of three more or less transverse dentine-loops, giving rise to six salient angles and four infolds; those of the outer side are poorly developed, especially in the m_3, in which when well-worn the anterior angle and infold may be absent. The first and second loops of m_2, and the second loop of m_3, especially the former, may be partially or completely divided into triangles.

The **sub-genera** *Craseomys* and *Phaulomys* indicate advanced specialisation, but seem to be rather of "group" than of higher value (see Anderson, *Ann. and Mag. Nat. Hist.*, Oct. 1909, 317, and May 1905, 493).

The genus contains a number of species, of circumpolar **distribution,** from the shores of the Polar Sea (introduced in Bering Island) through arctic, boreal, transitional, and sometimes subtropical zones, but absent from Greenland, the islands of the Polar Sea, Newfoundland, Spitzbergen, Novaya Zemlya, and Iceland. South it ranges in North America to the mountains of North Carolina and Colorado, with the sea-coasts of New Jersey and Northern Carolina; and in Europe to the Pyrenees (*not* in Iberia), the mountains of southern Italy, Rumania, and Trebizond. In Asia, it reaches the Thian-Shan and Kinghan Mountains of Mongolia; Pekin and the Shansi Mountains (8000 feet) of North China; Korea, Sakhalin, and Japan, from Hokkaido (Yezo), to Kiushiu.

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[1] This is variably developed in the different species; it is present in about 25 per cent. of *E. g. britannicus.*

Its southern habitats are usually in mountains (as *E. nageri hallucalis* of southern Italy and *E. brevicaudus* of Black Hills, S. Dakota), where they may be quite isolated; and in North America these detached colonies have been found in what are practically cool faunal islands surrounded by warmer zones far south of the ordinary range of their species (see Miller, *Science*, 4th November 1898, 615-616).

E. smithii is remarkable because, although a member of an hypothetically "arctic" genus, abundant in the British Pleistocene, and at Ightham accompanying such nominally "arctic" forms as *Lemmus* and *Dicrostonyx*, it is common in the two semi-tropical islands of Shikoku and Kiushiu, Japan (Thomas, *Proc. Zool. Soc.*, London, 1905, ii., 355). Thus, in *Evotomys*, as in true *Lepus*, the various species may be found in very different climates, so that the occurrence of a member of the genus in any particular geological deposit cannot in itself be regarded as evidence of climate.

Distribution in time:—The earliest remains of the genus yet discovered are those from the late pliocene Forest Bed of Norfolk. Others are known from the High and earlier Middle Terrace deposits of the Thames valley (lower and middle Pleistocene), but all are too fragmentary for specific determination.

Origin:—As a circumpolar genus, *Evotomys* may be compared with (restricted) *Lepus*, especially in its isolated southern colonies, its absence from North Africa and presence in Japan, but in the latter country it ranges much farther south than *Lepus*. Unlike *Lepus*, it is a generalised type, which no doubt largely accounts for its survival against the competition of modern forms. Like *Lepus*, its more specialised representatives have now become restricted to inhospitable arctic regions, mountains or islands. Like *Lepus*, it is older than the separation of the Old and New Worlds, and its presence in Kiushiu, but absence from Newfoundland, Greenland, and Iceland, suggest an Asiatic origin with dispersal to North America by an old land connection across Bering Sea.

THE BANK MOUSE.[1]

EVOTOMYS GLAREOLUS (Schreber).

EVOTOMYS GLAREOLUS BRITANNICUS[2] (Miller).

1774. MUS GLAREOLUS (species), J. C. D. von Schreber, *Die Säugthiere*, iv., 680, pl. 190 B; described from Laaland Island, Denmark.

1831. HYPUDACUS (misprint for HYPUDÆUS) HERCYNICUS (species), E. Mehlis, Oken's *Isis*, viii., 876; described from the higher Harz Mountains, Germany (HYPUDÆUS and HYPUDEUS occur also in the same article).

1834. HYPUDÆUS GLAREOLUS (species), H. B. Melchior, *Den danske Stats og Norges Pattedyr*, 116; identifying *Mus glareolus* of Schreber.

1832. ARVICOLA RIPARIA, William Yarrell, *Proc. Zool. Soc.* (London), 22nd May, 109, and Loudon's *Mag. Nat. Hist.*, v., 1832, 599; described from Birchanger, Essex, England; preoccupied by *Arvicola riparius*, Ord, 1825=*Microtus pennsylvanicus* (Ord) of North America; Jenyns.

1837. ARVICOLA PRATENSIS, Thomas Bell, *History of British Quadrupeds*, ed. i., 330; Boyd Dawkins and Sanford, *British Pleistocene Mammalia*, 1866, xiv and xxxvi (? part); Boyd Dawkins, "Distribution of the British Post-Glacial Mammals," *Quart. Journ. Geol. Soc.*, xxv., 1869, 194 and 196 (? part); MacGillivray; Owen (? part); Morris, *Cat. Brit. Foss.*, ed. ii., 1854, 357 (? part); from F. Cuvier's *Hist. Nat. des Mammifères*, vii., *Tab. Gen. et Méth.*, 1842 (described and figured in livr. 68, 1834)=*E. glareolus* (Schreber).

1870. ARVICOLA GLAREOLUS, W. A. Sanford, *Quart. Journ. Geol. Soc.*, xxvi., i., 124 (? part); Blackmore and Alston, *Proc. Zool. Soc.* (London), 16th June 1874, 461 (? part); Alston, in Bell, ed. ii., 1874; Newton, *Vertebrata of Forest Bed*, 1882, 82, pl. xiv., fig. 1 (? part); Lydekker, *Cat. Foss. Mamm. Brit. Mus.*, i., 233, 1885 (? part); Flower and Lydekker (? part); Harting, *Zoologist*, 1887, 361, pl. v.

1881. ? ARVICOLA (EVOTOMYS) GLAREOLA (part), E. T. Newton, *Geol. Mag.*, June, 258.

1890. MICROTUS GLAREOLUS (part), A. Smith Woodward and C. D. Sherborn, *Cat. British Fossil Vertebrata*, 365; Lydekker; Aflalo.

1898. EVOTOMYS GLAREOLUS, Oldfield Thomas, *Zoologist*, 101; Johnston; Miller, *Ann. and Mag. Nat. Hist.*, 1909, 419; Pycraft, British Museum *Guide to British Vertebrates*; Millais.

1900. EVOTOMYS HERCYNICUS BRITTANICUS (*sic*), G. S. Miller, *Proc. Wash. Acad. Sci.*, ii., 26th July, 103; described from Basingstoke, Hampshire.

1903. EVOTOMYS GLAREOLUS BRITANNICUS, G. E. H. Barrett-Hamilton, *Proc. Roy. Irish Acad.*, 11th May, 317; Miller (*Catalogue*).

1910. EVOTOMYS GLAREOLUS BRITANNICUS, E. L. Trouessart, *Faune des Mammifères d'Europe*, 170.

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[1] Bank or Red Vole of authors.

[2] First spelt *brittanicus*, but later corrected by the author to *britannicus*.

Synonymy:—The first three items refer to the species *glareolus;* the remainder to the British sub-species *britannicus.* Schreber's description and figure of *glareolus* are so poor that doubts have been expressed (by Miller) as to the identity of the animal thus named, but, since Melchior applied the name *glareolus* to the Danish *Evotomys*, and nothing in Schreber's description is inconsistent with Melchior's determination, the name, which has been widely accepted, is entitled to stand, thus avoiding resuscitation of Melchior's *hercynicus.* The species was mentioned for the first time by Pallas (*Novæ Species Quad e Glirium*, 247), who considered it a variety of his *Mus rutilus.*

Terminology and local names:—The species is not distinguished locally, the following being merely book names:—Bank Campagnol (translating the technical name *riparia*), Yarrell, 1832; Jenyns, 1835. Bank Vole, Bell, ed. i., 1837, and ed. ii., 1874; Lydekker, 1895; Thomas, 1898; Johnston, 1903; Millais, 1905; and most modern authors. Red or Meadow Vole, MacGillivray, 1838. Red Field Vole, Alston, in Bell, ed. ii., 1874. Red Vole or Wood Vole, Johnston, 1903. Red-backed Meadow-Mouse, English. Red-backed Mouse of American writers. The word "vole" being, as explained above (p. 398), objectionable, the name "Bank Mouse" would seem to be appropriate.

History and status:—The Bank Mouse of Britain was first described in 1832 by Yarrell, who believed it to be new to science. Soon afterwards, specimens were forthcoming from several counties, and Bell rightly referred them to the present species already known by several synonyms. Jenyns also reached the same conclusion (*Ann. and Mag. Nat. Hist.*, June 1841, 270) after examining one taken by William Thompson at Aberarder, Inverness-shire (see Charlesworth's *Mag. Nat. Hist.*, 2nd ser., iii., 1839, 585). Other early discoverers of it were Selby in Northumberland (*Mag. Zool. and Bot.*, ii., 1838, 92); Eyton in Shropshire (*Ann. Nat. Hist.*, Feb. 1840, 397), and Bond in Middlesex (*Zoologist*, 1887, 425). In Scotland it was first identified by MacGillivray, who, previously to 1838, examined specimens taken by Weir at Bathgate, Linlithgowshire; Edward also found it in Banffshire (Smiles's *Life of a Scotch Naturalist*, ed. i., 1876, App., 393). It was long reputed a rarity, as shown by the comparatively recent dates of first records for many counties where it is now well known, and it was not until after the introduction of efficient methods of trapping that its status in Britain was recognised. Although far below specific rank, the British Bank Mouse is, from its deep coloration, an easily recognisable sub-species when a series of specimens are examined.

Distribution:—The species *glareolus* is found usually in wooded districts, but not in the higher mountains, through boreal and temperate Europe, exclusive of the Iberian Peninsula, from Scotland, Skandinavia, and corresponding latitudes in Russia, south to the Pyrenees, southern Italy, and Rumania; east and west it ranges from Wales, at least to the Syansk Mountains, 100 miles west of Lake Baikal, where it ascends to 1600 feet.

The sub-species *britannicus* is confined to **Britain.** It is absent from Ireland, the Isle of Man, the Hebrides, Orkneys, and Shetlands; but is common throughout England, Wales, the lowlands of Scotland, and north to the districts adjoining the south coast of the Moray Firth, with the islands of Anglesey (Oldham), Wight (More), and Bute. It does not ascend the mountains to any great height, though on the latter point details are lacking for England and Wales (recorded from 600 feet in Cheshire by Coward; and 700 feet near Bridge of Allan, W. Evans, *MS.*). In Scotland it is characteristic of the valleys and cultivated districts rather than the moors and uplands, where it gives way to *Microtus;* when found on the moors it affects the boulder-strewn hollows rather than the open ground (Gordon). Its distribution has not yet been worked out for the Highlands, where it may eventually prove to be more common than the present meagre records would warrant. For instance, at Loch Awe, Argyll, the first record was that of C. H. Alston in *Ann. Scott. Nat. Hist.*, 1905, 52; the mouse had been previously unnoticed, yet it is much commoner than *Microtus* (Alston, *MS.*). It is not yet known from Sutherland or Caithness, the most northern record being that of Hinxman and Clarke for Braemore, West Ross-shire (*Proc. Roy. Phys. Soc.*, Edinburgh, 12th June 1894, 394); this fact, taken in conjunction with Cocks's experience in Buckinghamshire, suggests that this may actually be an increasing species, which may really have been rare until recent years.

Distribution in time and origin:—*E. glareolus* is not known earlier than the late pleistocene fauna of Ightham, Kent, where it occurs, as a distinct sub-species, with other forms now extinct. Its present distribution and absence from Spain indicate a recent arrival from the East, which reached Britain before the separation of Anglesey, Wight, and Bute, but after that of Ireland, Man, and the Scottish Islands. It does not yet seem to have had time to thoroughly overrun Scotland.

Description:—The general appearance of the Bank Mouse has been indicated above under the genus *Evotomys.*

The sparsely-haired ears are usually described as longer than in the Grass Mouse, but actually owe their conspicuousness rather to the shorter fur, which they overtop, than to any proportionately larger size; when laid forward they do not quite reach to the eyes. The densely-haired tail has a distinct terminal pencil, and reaches a length about half that of the head and body. The muzzle-pad is small and inconspicuous, and is crossed by a narrow median cleft running upwards from the upper lip. The lips are pink. In each hand the thumb is rudimentary, with minute nail. Digit five reaches to the base of four; three is slightly longer than four, and four than two. There are five large normally placed pads; the intervening skin is finely tuberculo-reticulate. In each foot the hallux reaches to the base of digit two; digit five slightly beyond the base of four; four, three, and two are subequal in order of length. There are six normally placed pads, smaller than those of the hand, especially the posterior; the intervening sole is naked and tuberculo-reticulate, densely haired behind.

Colour:—The reddish mantle extends from the forehead in front of the eyes to the base of the tail, and is usually near "vandyke brown," strongly washed with "cinnamon rufous," and sprinkled with longer black hairs; the flanks, cheeks, and the face before the eyes are lighter. There is no distinct line of demarcation. The under side is whitish, frequently washed to a variable extent with yellowish or buff; the feet are greyish, the tail inconspicuously bicoloured. The colours are lighter red when faded, as in late winter.

The carpal vibrissæ appear with the first pelage in the nest. The whiskers reach a length of from 22 to 28 mm.

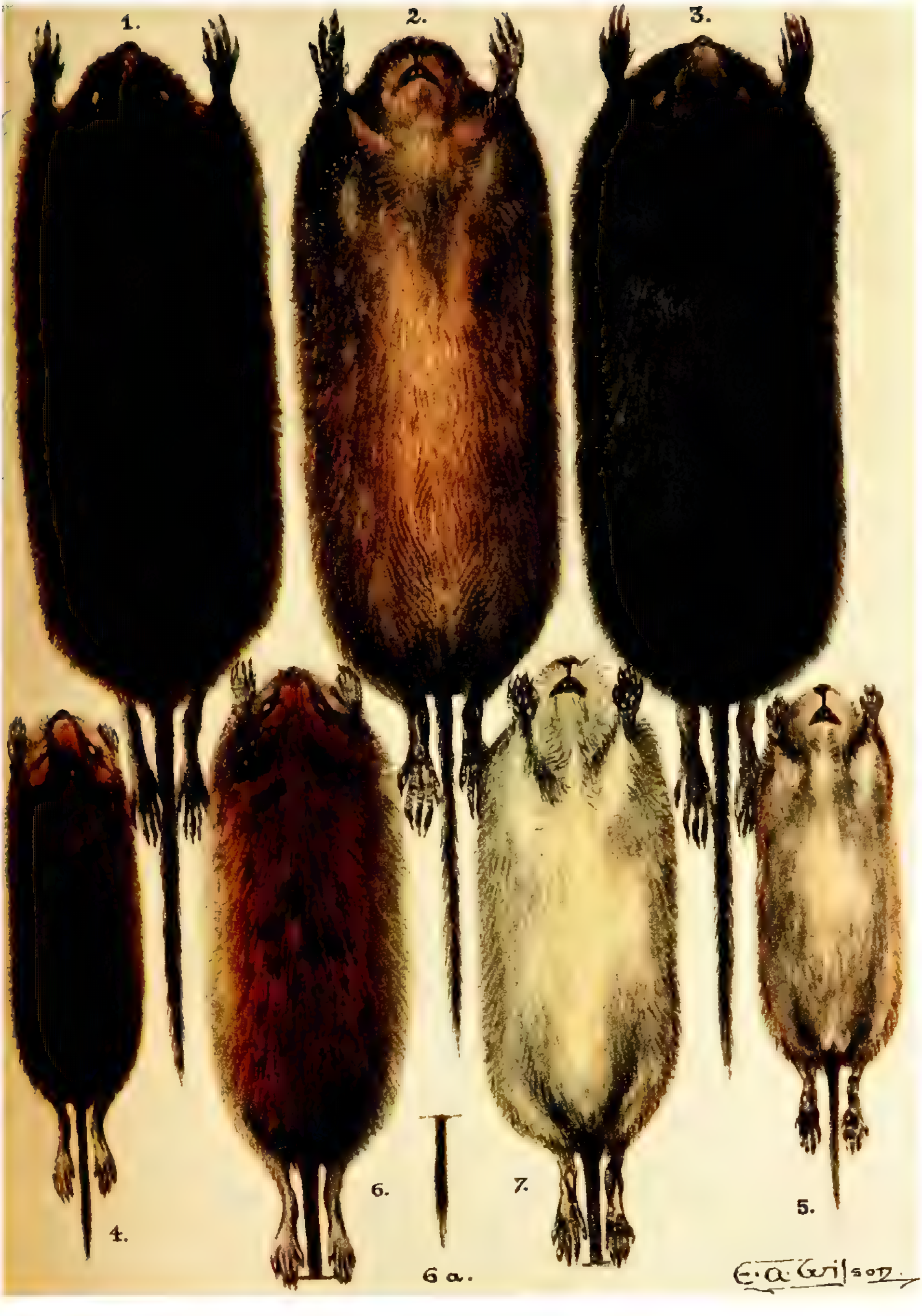
Moult; a coarser coat is assumed in October, after which in cold localities the flanks may be greyer, as in *Sciurus*. A moult has also been observed in early May (8th) [and by Collett in July or August in the Norwegian *Evotomys*].

The **young** have the upper side less brightly coloured. In the woolly juvenal coat the under side is at first dusky; later, as longer hairs with light tips increase in number, the characteristic tints of the adult are gradually assumed, at first on the upper side, but a buff or yellowish belly, when present, is characteristic of the adult pelage, hence it is most conspicuous in winter.

There is some **local variation**. Specimens from Scotland (W. Evans) and Anglesey (Oldham, *Zoologist*, 1895, 302) are said to show very dull tints as compared, for instance, with those from near Swansea. At Reigate, Surrey, adults have a greyish-white belly; this is purer white in Hertfordshire, most brilliant in winter (Adams). The subject requires investigation by local naturalists. Occasionally a specimen has the mantle so pale and the sides, cheeks, and face so grey as to recall the coloration of continental sub-species. The most pronounced of these are from Scotland, where also Millais believes that the average size is larger.

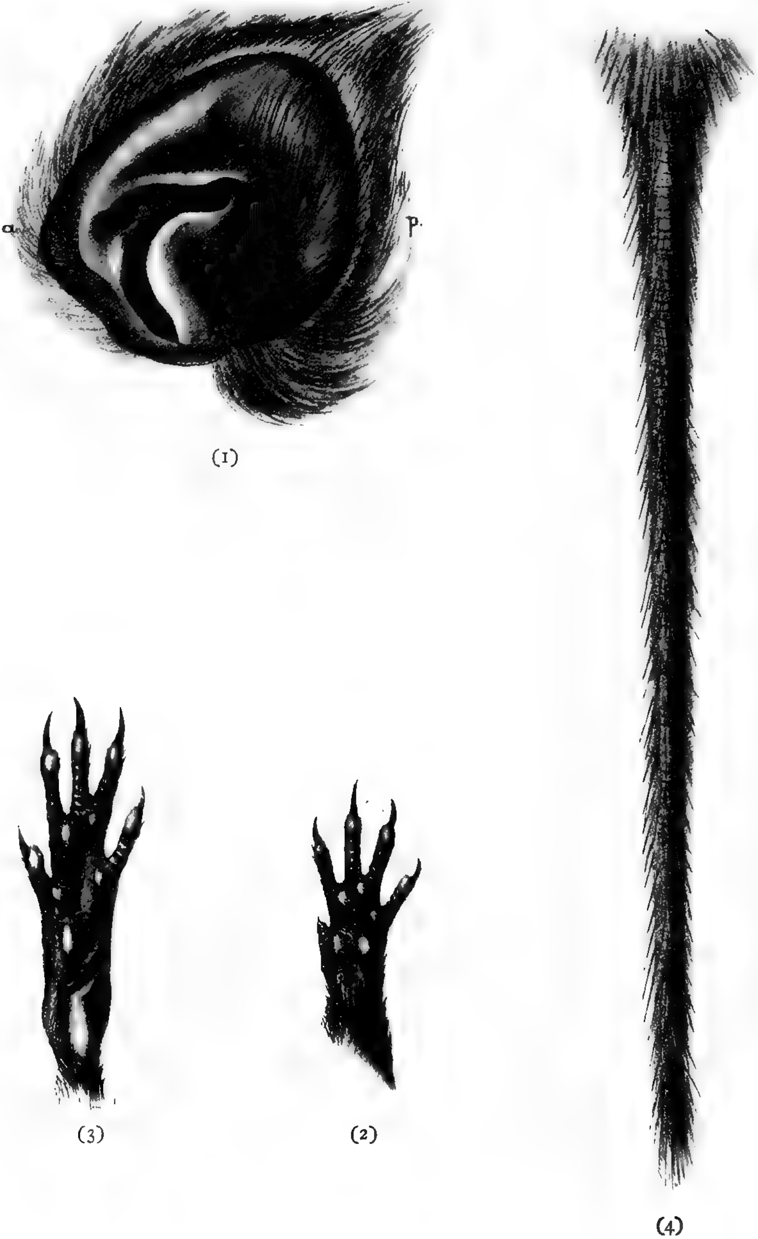
For the **skull** and **teeth**, see description of genus *Evotomys*. m^3 is usually simple, having on each side three well-defined salient angles and two infolds.

Exceptional variation:—Forrest has sent me a note of a melanic individual taken at Ellesmere, Shropshire; the whole animal was uniform dull brownish-black. Several entirely or partially albinic


1.
2.
3.
4.
6.
7.
5.
6 a.
E. A. Wilson

BRITISH *Microtinæ* (SKINS);
(1, 2) *Arvicola amphibia amphibia*; (3) *A. a. reta*; (4, 5) *Evotomys glareolus*; (6, 7) *E. skomerensis.*

PLATE XXVI.



THE WATER RAT.

(1) LEFT EAR (2½ times life size) ; (2) LEFT HAND and (3) LEFT FOOT (both 1½ times life size) ; (4) TAIL, viewed from above (life size). *a* = anterior ; *p* = posterior.

specimens have been recorded; *e.g.*, (1) cream-coloured, from Hertfordshire, in J. Whitaker's collection; (2) with white patch on head (D'Urban, *Zoologist*, 1879, 265); (3) white with pink eyes and light sandy tint on back, Essex, identified by Bartlett (Rosling, *Journ. cit.*, 1885, 433); (4) light cream with red eyes, Huntingdonshire (Bond, *Journ. cit.*, 1887, 425); (5) white female with slight rufous tinge on upper side, Bedfordshire, No. 98.2.27.1 of British Museum collection.

Geographical variation: — The following may be regarded as sub-species:—(1) *E. g. glareolus* (Schreber) of West-Central Europe, from the Baltic to the Alps and Pyrenees and from the Atlantic coast to Silesia, is brighter in colour, and perhaps on the average (hind foot, 16·6 to 18; condylo-basal length of skull, 23 to 24·6 mm.) slightly larger than (2) *E. g. britannicus.* (3) *E. g. suecicus* (Miller) of the Swedish and Finnish lowlands with the south-eastern watershed of Norway, has the red mantle narrower and the sides and face greyer than in *E. g. glareolus.* (4) *E. g. istericus* (Miller) of the Danube basin, from Bavaria through Hungary to Rumania, and probably to Bulgaria and the Black Sea coast, has also a narrow mantle, but is lighter and yellower, and has the auditory bullæ more abruptly inflated on the inner side. (5) *E. g. helveticus* (Miller) of the Jura Mountains, the non-Alpine parts of Switzerland, and the lower western French Alps, is a pale buffy-grey form with the hind foot 17 to 19 and the condylo-basal length of skull 23 to 25·4 mm. (6) *E. g. saianicus* (Thomas) of the Syansk Mountains, Lake Baikal, is a small grey form with short brain-case, hind foot 16, and condylo-basal length of skull 23 mm.

DIMENSIONS IN MILLIMETRES AND WEIGHT IN GRAMMES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.[*]					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. Male, 20th Sept. 1909, caught running in lane; juvenal pelage	63	29	17		..
2. Male, 7th Oct. 1909; found dead; juvenal pelage	64	30	15		
3. Male, 25th June 1909	65	33	15	..	..
4. Female, 5th Aug. 1909; juvenal pelage	72	35	16	..	12
5 Male, 17th Jan. 1909; juvenal pelage .	73	40	16	..	12
6. Male, 20th Sept. 1911; adult pelage .	74	41	15	10	12
7. Male, 21st Jan. 1909; almost adult pelage	75	39	16·5	..	13
8. Male, 7th June 1911; juvenal pelage .	75	35	16	10	9
9. Male, 10th Oct. 1912	78	39	15	9	12
10. Female, 10th Oct. 1912	90	46	17	10	20

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[*] Adams's results agree closely with those of other observers, as Hollis (MS.) in Devon, and with the average for all Britain, as shown by specimens in the British Museum; they may fairly be taken as representative for the sub-species *britannicus*. All the specimens were dissected.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY (*continued*).					
SEXUALLY MATURE MALES:—					
1.	96	48	16·5	11	22
2.	95	46	16	10·5	21
3.	88	42	16	10	18
4.	100	47	16	11	20
5.	95	47	16	11	19
6.	88	43	15·5	12	20
7.	97	50	15	12	23·5
8.	85	46	15	11	16·5
9.	92	48	16	11	22·5
10.	90	47	16	11	17
11.	90	40	15	10	16
12.	88	41	17	11	17
13.	92	43	16	11	19·5
14.	89	45	17	10	16
15.	93	47	17	12	17
16.	90	47	17	11	19
17.	88	50	17	11	17
18.	86	55	17	11	18
19.	88	43	16	10	16
20.	90	45	17	11	17
Average	91	46·2	16·2	11 (nearly)	18·6
Average of 36, from various localities, in British Museum	93	43	16·25	11	
Maximum	104	55	18	12	.
SEXUALLY MATURE FEMALES:—					
1.	95	45	16	12	21·5
2.	95	49	16	11·5	21
3.	105	45	16	13	23
4.	100	52	16	11	23
5.	100	51	17	11·5	21
6.	97	55	15·5	12	23
7.	86	40	17	11	17
8.	93	46	16	11	17·5
9.	90	41	16	12	22
10.	90	47	16	11	18
11.	103	53	16·5	13	26
12.	94	51	16	11	20
13.	85	43	16	11	16
14.	86	49	17	12	17
15.	84	44	17	12	14·5
16.	93	49	17	11·5	21
17.	90	46	17	11	16
18.	96	55	17	12	22
19.	89	46	16	11·5	20
20.	81	44	16	11	17
Average	92·6	47·5	16·3	11·6	19·8
Average of 38, from various localities, in British Museum	93	43	16·25	11	
Maximum	117 *	51	18	13	..

* One, Kent, 114 (converted from inches; see Grabham, *Zoologist*, 1896, 497).

Remarks.—Adams finds young in the nurseries until their external dimensions reach about 65-33-15; they then run about and may be trapped, so they are presumably about fourteen days old (see Roberts's observations below on p. 417). Many remain sexually immature until the head and body reach 85; Adams examined one breeding female of 81; another of 85 contained two embryos. At about 85 adult pelage is assumed, and from 90 upwards the majority are sexually mature. Many grow on to a much greater size, and, in exceptional cases, females have been found to be sexually immature at 97 or 99. It is not clear whether dimensions exceeding 100 are abnormal, or whether every individual would reach that size if not previously destroyed. Apparently they continue to grow for a long time, and Millais finds that all *Microti* improve considerably in colour and size until they are two years old. There is nothing to show that the sexes differ constantly in size.

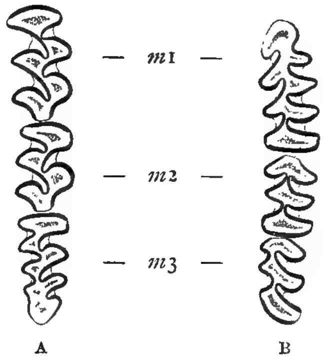

FIG. 63.—CHEEK-TEETH OF *Evotomys skomerensis* (A, right upper; B, left lower; 7 times life size). (Drawn by M. A. C. Hinton.)

Skull:—Condylo-basal length, 21·2 to 24·2; breadth at zygomata, 12·2 to 14; at inter-orbital constriction, 3·6 to 4·2; at occiput, 10·7 to 11·8; median occipital depth, 5·8 to 6·4; greatest length of nasals, 5·6 to 7·4; of diastema, 5·6 to 7·2; of mandible, 12·8 to 14·8; of maxillary tooth-row, 4·8 to 5·6; of mandibular tooth-row, 4·8 to 5·4.

Distinguishing characters:—As between mice of this genus and others of similar size, the hairy, bicoloured tail is probably the most distinctive external character. Its length, about half that of the head and body, is greater than that of any *Microtus*, shorter than that of any member of the sub-family *Murinæ*. In the skull the simple palate, rooted cheek-teeth with rounded salient angles, and transversely open triangles of m_2 are diagnostic. The characters of the other species of *Evotomys* are given under their special headings.

The Bank Mouse[1] is not specialised by its structure for a narrow type of existence. Its habits are, therefore, of comparatively wide range, but not strikingly peculiar in any particular direction. It may be found in all the situations ordinarily affected by Grass Mice or Field Mice, without, however, adopting the extreme rôle of either. In demeanour and activity it is quite intermediate, being less fossorial, but much more rapid and agile in all its movements, than the Grass

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[1] Of earlier original accounts that of E. R. Alston, in Bell's second edition, usually, but incorrectly attributed to Bell himself, is, considering the date, 1874, perhaps the best. Other original accounts are those of G. T. Rope, *Science Gossip*, July 1886, 155-7; and of Douglas English, *Some Smaller British Mammals* (undated).

Mouse. On the other hand, although quick and sprightly, a capable climber and a fair jumper, it is in all these respects quite inferior to the Field Mouse.

As an instance of its powers of running, Mr Rope reminds me of the speed with which it will cross a road; and Mr English knew one to escape from a square biscuit-tin, with sides $9\frac{1}{4}$ in. high, that being about the limit of leap attainable by the species, though 7 in. is well within its average powers.[1] The same writer finds it gnawing through wood as rapidly as a House Mouse.

It is active at intervals throughout the day as well as at night; its most favoured haunts being hedgerows, railway-banks, old walls, woods[2] or gardens, especially where the presence of roots, stones, heaps of sticks, or recesses makes the construction of runs easy. It usually prefers warm, dry, sunny situations, yet frequently inhabits wet localities. It swims well, and has been known to escape pursuit[3] by diving, or to recover grains of maize from the bottom of a feeding-trough.[4] Charles St John[5] seems to have met with it living on sandhills by the seashore, where he suggested that its food is grass seeds and dead fish.[6]

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[1] F. Head (*Zoologist*, 1888, 24) credits it with springs of a foot upwards, and a similar distance was recorded for its leaps from shelf to shelf of a greenhouse by G. Dalgliesh (*Journ. cit.*, 1907, 302).

[2] Hence its rufous dorsal mantle is thought by some writers to be protective, as harmonising with a background of dead leaves (Ernest Thompson Seton, I, 509). If so, it is curiously different from the tints of other small mammals, such as shrews, which live amongst similar surroundings. Arising as it does from a dull-coloured juvenile pelage, and being characteristic of the genus in many varying climates and environments, it seems difficult to say more than that it is an indefinite colour, the exact tint of which depends on the chemistry of the ancestors of the genus, and now to a limited extent on climatic environment rather than on escape from enemies. In some exotic species the colour has not been perfectly developed. The North American *E. gapperi* is sometimes dichromatic, having a phase in which the rufous are replaced by sooty tints (G. S. Miller, *Proc. Boston Soc. Nat. Hist.*, April 1897, 16). *E. proteus*, Bangs, of Labrador, shows wide colour-variation, the back varying from mouse-brown to bright rufous (Outram Bangs, *Proc. Biol. Soc. Wash.*, xi., pl. iv., 17th September 1897, 239). Some forms are very brown, *e.g.*, Thomas's *E. frater* of Thian-Shan. *E. smithii* of Japan has the young dark slate-coloured.

[3] In Norway; Robert Collett.

[4] William Borrer, *Zoologist*, 1887, 462.

[5] *Natural History and Sport in Moray*, ed. 1882, 257.

[6] The specimens from which J. C. D. von Schreber described his *glareolus* were caught amongst beds of sea grass (*Elymus*). In similar situations on Bering Island, Kamchatka, *E. wosnessenskii* accompanies the grass to its seaward limit, and in such localities L. Stejneger and I sometimes found it very plentiful.

Although it is often content to dispense with the "runs" which are so characteristic of the more sedentary Grass Mouse, a colony in permanent occupation of a bank or hedgerow usually constructs a complicated series of shallow galleries, partially below the ground. These have been carefully excavated by Mr L. E. Adams, who has supplied me with several plans of them (Fig. 64). They are of irregular construction and diameter, with numerous openings, blind terminals, and enlarged chambers, which may extend for a considerable distance along a bank. There is generally a more or less central highway, which is used by all wandering mice or shrews in common. That intercommunication is the sole or main object of the runs examined by Mr Adams seems to be proved by the entire absence from them of nests, traces of food, or other signs of occupation. It may be that in a southern county like Surrey

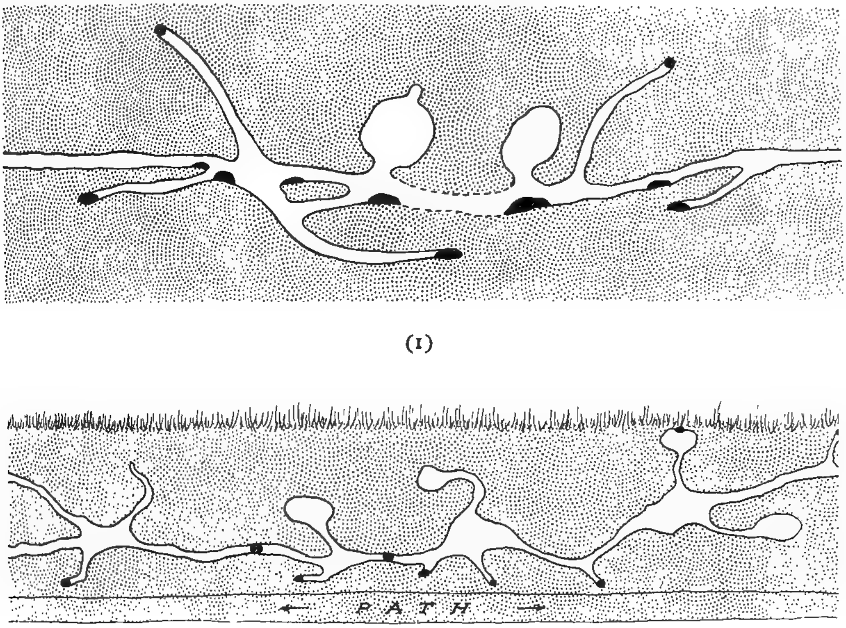

FIG. 64.—DIAGRAMS OF (1) BURROWS OF BANK MOUSE; (2) A GENERAL MURINE HIGHWAY IN A HEDGEROW, probably constructed in the first instance by Bank Mice. The black spots indicate the entrances to the burrow. (From plans and sketches supplied by L. E. Adams.)

the mice sleep without regular couches wherever they may happen to be overtaken by drowsiness, but in more northern localities they certainly construct dormitories and accumulate food-stores,[1] especially in winter. It seems likely that the highways are a special feature connected with southern agriculture and enclosed fields, and in such extensive burrows a variety of antagonistic species might pass to and fro in safety, concealed from each other by the darkness and absence of distinct "scent."[2]

This is a bold species, not timorous of observation by man, and devoid of suspicion of traps, which, as for the Common Shrew, are most successful when most conspicuous. Almost any bait, from nuts to meat, is efficacious. If a mouse be seen running along a hedgerow, and a trap be then set, a capture may frequently be effected within a short time.[3]

Though fond of green stuff, the Bank Mouse perhaps more frequently[4] consumes roots, kernels, nuts, fruits, berries, grain or seeds.[5] Its love for bulbs, carnations, peas, and roots makes it a pest in gardens. In spring it ascends the shrubs of the hedgerow to nibble away the tender leaves,[6] and in autumn climbs for hips and haws. These are frequently carried off to a burrow and eaten at the entrance, or to a disused bird's nest, where a heap of rejectamenta betrays the feasts.[7] Both the kernels and flesh of hips may be eaten, and a hole is rapidly cut through the shell of a filbert or hazel nut, through which the contents are extracted. The shell is pierced in about a minute; the kernel extracted in about an equal time. Gooseberries are treated like nuts, being neatly emptied of their contents by a hole in the side.[8] Apart, however, from the necessary boring of a hole, it (like other mice) differs from the Dormouse in having no regular plan of attack. Mr English has observed that when carrying a nut to its burrow or store it uses the three methods in use amongst rats: it either seizes the pointed end between the teeth and jumps along with head high in the air, or it wedges the burden between the chin and fore legs, or rolls it along the ground.

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[1] See below, p. 436.
[2] *Cf.* above, article *Rabbit*, p. 205.
[3] The first two specimens of *E. cæsarius* of Jersey were thus taken by me, traps being placed where the mice were seen running about at 11 A.M., and taken up before dark. Borrer (*op. cit.*) once had a wild Bank Mouse sitting on his foot.
[4] As is shown by the fact that in captivity it will not survive long without hard food (A. H. Cocks).
[5] In Norway an *Evotomys* was caught hurrying off with seven grains of barley in its mouth (Collett).
[6] Especially of wild rose and hawthorn: see W. Evans; F. Coburn, *Zoologist*, 1894, 303.
[7] J. H. Teesdale, *Journ. cit.*, 1895, 186. Cocks reports (January 1914) a blackbird's nest in a hedge quite full of nibbled hips.
[8] Alston, *Zoologist*, 1866, 9-10.

The Bank Mouse sometimes causes damage to young plantations, but this seems to occur chiefly in Scotland;[1] climbing the trees, it eats out the buds, especially of larch, and devours the bark to the end of the branches, which, if very small, are first gnawed off and allowed to drop.

Sometimes in its climbing expeditions it accidentally meets with booty in young birds,[2] and it is stated to be fond of many kinds of insects, and of molluscs.[3] Lastly, it is an inveterate cannibal, and in captivity has been known to kill and devour the reputedly unpalatable Common Shrew.[4] It may thus be described as omnivorous and cannibalistic in contrast to the almost entirely vegetarian, though also cannibalistic, Grass Mouse.[5] Its diet is well shown by the ordinary contents of its stomach, a yellow substance "like pease-pudding," in contrast to the chewed grass to be found in those of entirely vegetarian species.[6]

In feeding, it either holds its food down with its fore paws, or sits upright and handles it like a Dormouse. When devouring the carcase of a fellow-mouse, although it never eats the skin, it does not invert it as would a shrew; it merely turns back as much of the skin as is necessary to get at the brain and thorax, after which the carcase usually receives no more attention.[7]

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[1] First reported by Rev. G. Gordon (*Zoologist*, 1844, 425), who later sent specimens to Alston (in Bell) from Morayshire; also mentioned by Service (*Solway*, 206); H. S. Gladstone for Dumfriesshire; Robert Thompson (*Nat. Hist. of a Highland Parish*, 82, 1900) for Nairnshire; and William Taylor for Llanbryde, near Elgin. Similarly in Norway, according to Collett, attacks are most conspicuous in the north, possibly as a result of scarcity of food on the ground.

[2] Victor Fatio.

[3] E.g. *Helix nemoralis*, and *H. aspersa;* C. Wright, per Adams.

[4] Alston, in Bell.

[5] The facts are well put by R. I. Pocock, *Zoologist*, 1897, 507.

[6] W. E. de Winton, in R. Lydekker.

[7] Adams, *MS.*

Occasionally it enters houses, and robs cupboards[1] and gardeners' stores;[2] but this does not seem to happen so often in the British Islands as in more northern countries—as in Norway, where in winter the habits of the local Bank Mice resemble those of the House Mice, which they accompany to the very roof.[3] In Norway also it accumulates stores of provisions. As stated above, the latter habit does not seem to be universal in this country, but Mr English once excavated five Bank Mice, and ninety-three cob-nuts, the latter all intact, and tightly packed together. In Britain it sometimes obtains both food and shelter by constructing a winter nest of short dry straw or grass in swede or potato clamps.[4]

It is a hardy mouse, and is not confined to its retreat in times of frost or snow.[5] Mr Adams found it the only species coming to traps at a temperature of 14° Fahrenheit.

The period of gestation was ascertained by Mr Robert Drane to be twenty-eight days, in a captive female which produced a second litter that number of days after isolation with a previous one.[6]

The young, which at birth are about as advanced in development as those of other mice,[7] are born during a long sexual season, which in the south of England lasts regularly from March to December inclusive, and probably includes also not infrequently January and February. Mr Adams gives the average of twenty litters as 3·8 young; he has examined in all 2 of six, 6 of five, 15 of four, 13 of three, and 2 of two. Very probably these figures include the litters of young mothers, and of unfavourable seasons. A series examined in the height of the sexual season should give larger results, and Mr Cocks reports a litter of eight found on 27th May 1911.

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[1] One caught in a cupboard at Vaynol Old Hall, Bangor, N. Wales, in September 1904, was forwarded to me by H. E. Forrest; Dalgliesh has also sent me a similar note; and see also Rope, *Zoologist*, 1898, 503.

[2] J. Sutton, *Journ. cit.*, 1888, 23.

[3] In the Yukon region W. H. Osgood found *E. dawsoni* always about log-cabins (*North Amer. Fauna*, No. 19, 1900, 34). In Kamchatka *E. wosnessenskii* frequents dwellings and accumulates stores of food often carried from quite a distance; thus sheltered, it rears young throughout the year, but on the tundra is inactive in winter; N. G. Buxton, in J. A. Allen, *Bull. Amer. Mus. Nat. Hist.*, 31st March 1903, 147-8.

[4] G. Roberts, *Zoologist*, 1866, 206; H. A. Macpherson, *Journ. cit.*, 1894, 149, and *Lakeland.*

[5] R. J. Cunninghame took specimens (British Museum) of the Norwegian *E. glareolus succicus* in January and February, on two or more feet of snow, in cold weather; and in that country *Evotomys* tunnels under the snow (Collett). More probably it objects rather to wet than to cold weather. In this connection it may be well to contrast the shrews, whose voracious appetite and rapid digestion compel activity in all weathers to avoid starvation, with the mice, which, although large eaters, have a slower digestion, and can exist much longer without food.

[6] Thus confirming F. Lataste's "law"; see above, p. 375; had she not been nursing, the young would presumably have been born on or about the 21st day.

[7] Lataste, 382.

The nurseries may be found, usually above ground, in hedgerows or hayfields. They are composed of grass, the interior bitten fine,[1] and a lining of moss, sheep's wool, or feathers[2] may be added; thus serving to distinguish the structure from that of the Grass Mouse, which only uses such luxurious materials in winter. Collett mentions a Norwegian nest which was placed on the roof of a house at a height of nearly 20 ft.; another was built into that of a Fieldfare, at 6 ft. from the ground, in a young spruce; it was domed, with a small entrance near the under side.

According to observations made on captives, young were observed with the eyes open on the fifth day from birth, at which time they were clothed with blackish down, and their whiskers began to show; on the seventh day they were brownish.[3] The members of another litter[4] began to move about when eleven days old, and at fourteen days were fully furred, active, and able to feed themselves.

Bank Mice have frequently been kept in captivity, and evidently vary much in individual disposition, being sometimes described as inoffensive and amiable, at others as shy, irreconcilable, and easily provoked to bite. Macpherson, for instance, had two, of which one was sullen and untamable; the other, which had a charming temperament, was eventually murdered and eaten by its companion. They are fond of preening their fur. They sleep with the head tucked away under the belly between the fore paws, and sometimes make a

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[1] English's captives cut stiff hay into lengths of 1 inch or less, which then gained breadth by splitting of themselves longitudinally.

[2] Fatio.

[3] English; the first date is so very early, that an error may be suspected, and it would be desirable to have confirmation of any date earlier than the eleventh day.

[4] T. V. Roberts, *Zoologist*, 1892, 329; see also *Nature Notes*, 1903, 130.

"form" for themselves like a hare. Several observers have found that they appreciate the well-known "wheel," which forms a regular appendage to cages for mice.

Any excitement such as fighting or pairing is accompanied by much squeaking, the voice being comparatively deep-toned, "a short, grunting squeak," neither so sharp nor so prolonged as that of the Field Mouse or House Mouse.[1] One in the possession of Mr F. Norgate[2] fought and squeaked at him when he robbed it of a laburnum seed. The mother of Mr T. V. Roberts's litter was most jealous of her young being seen, and freely carried them about in her mouth, or, when they grew older, drove them into their sleeping compartment. The mother of Mr English's attacked him in defence of her young, and died when caught.[3]

Bank Mice are quarrelsome to their own species, and in fighting make a great fuss; grinding their teeth, they stand upright on their hind legs, and hop round each other, stretching out their fore paws for protection, or bending backwards to avoid attacks.[4]

This mouse is not usually associated with "mouse plagues," but Collett mentions several in Norway, chiefly in the north of the country. When food is abundant the numbers increase proportionately, and Mr Cocks noticed that the exceptional beech-mast harvest of 1900 resulted in great swarms of this species and of the Field Mouse at Poynetts, Buckinghamshire; the normal numbers were not resumed until the following summer. Mr J. G. Millais[5] and Mr de Winton[6] attribute the devastation of the Forest of Dean, Gloucester, in 1813-1814, to Bank Mice. Except the fact that woods, and not pastures, were destroyed, and Edward Jesse's description[7] of the "short-tailed mouse" concerned as having the upper parts "of a reddish brown," there is no evidence in support of this supposition. The tint mentioned would quite well describe the Grass Mouse, which is ready enough to attack woods in times of superabundance. It is, however, most probable that Bank Mice are often present amongst the hordes of Grass Mice in "mouse-years." Great numbers of mice were reported from woods at Faldonside, Berwickshire, in the winter of 1882-1883, and a specimen sent to Mr James Hardy[1] for identification proved to be of the present species. In 1888 the Bank Mouse was very abundant in Leigh Woods, Bristol District, having been seen in small scattered parties of eight or ten travelling steadily down the valleys.[2]

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[1] Rope, *op. cit.* The pairing shriek is "un cri aigu et chevrotant, qui rappelle celui de la Fauvette" (Lataste, 382); Collett states that when two meet (in Norway) they frequently utter a loud "tyee-tyew-tyew-tyee," the syllables repeated in rapid succession.

[2] *Zoologist*, 1874, 4236.

[3] For accounts of captive Bank Mice, see Rev. H. H. Slater, *Zoologist*, 1887, 462; E. R. Alston, Rope, Head (very tame), T. V. Roberts, *opp. cit.;* and Macpherson, *Zoologist*, 1894, 149.

[4] Rope. [5] ii., 247. [6] In Lydekker.

[7] *Gleanings in Natural History*, 6th ed., 1845, 111-114.

There are few records of the longevity of this mouse, the maximum duration in the Zoological Society's Gardens having been fourteen months.

THE SKOMER BANK MOUSE, OR DRANE'S MOUSE.

EVOTOMYS SKOMERENSIS, Barrett-Hamilton.

1903. EVOTOMYS SKOMERENSIS, G. E. H. Barrett-Hamilton, *Proc. Roy. Irish Acad.*, 11th May, 316; described from Skomer Island, Wales (type specimen, No. 3.7.4.3 of British Museum collection); Trouessart; Miller; Pycraft, British Museum, *Guide to British Vertebrates.*

1903. EVOTOMYS SCOMERENSIS, R. Lydekker, *Zoological Record*, *Mammals*, 34 (misprint).

1905. EVOTOMYS HERCYNICUS SKOMERENSIS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 250.

Distribution:—This mouse is only known from Skomer Island, off the coast of Pembrokeshire, Wales.

Description:—It differs from the Common Bank Mouse in its larger size; in the exceptionally light and bright colour of the upper side, which is in sharp contrast to the buffy white under-side; in its large, massive skull, and in the complicated form of m^3.

In late winter or spring the mantle is broad, encroaching considerably on the paler sides; its general **colour** is between "orange rufous," bright "cinnamon rufous," and "madder brown." On the face, sides of the head, and flanks the bright rufous tints are less conspicuous, running through light "hazel" or "vinaceous cinnamon" to a dull "greyish buff." The rump and the upper side of the sharply bicoloured tail are "mummy brown." The under-side of the body and tail, with the legs and feet, are whitish, usually with a very perceptible wash of yellowish on the belly.

The large, unusually ridged and angular **skull** needs no comparison with that of *E. g. britannicus.* From those of *E. nageri nageri* and *E. n. norvegicus* (see next page), which agree with it in size, it differs in its great relative depth, in the short, broad, rather strongly ridged and angled brain-case, conspicuous mastoid region, and unusually elongate, centrally contracted almost spatulate nasals, which are decidedly longer than the diastema. The post-orbital processes of the squamosals are small, but unusually well defined, and send well-developed ridges backwards and upwards nearly to the anterior edges of the parietals.

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[1] *Proc. Berwickshire Nat. Club*, x., ii., 278, 1885.

[2] H. J. Charbonnier.

The **cheek-teeth** are large, and similar to those of *nageri*, m^3 having normally three infolds on the inner side (Fig. 63).

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
1. Male, 7th April 1900 (No. 3.7.4.3 of British Museum collection), Y. H. Mills (type of species) . .	108	59	18	13
2. Seven males and five females—				
Minimum .	105	50	17	12
Average . .	109·5	55·5	18	13·5
Maximum . .	114	61	19	15
3. One mentioned by Miller . .	121	..	..	

Skull:—Condylo-basal length, 24·8 to 25·8; breadth at zygomata 14·2 to 15; at inter-orbital constriction, 4 to 4·2; at occiput, 12 to 12·6; median occipital depth, 6·4 to 7·0; greatest length of nasals, 7·6 to 8·2; of diastema, 6·8 to 7·2; of mandible, 15·6 to 16·4; of maxillary tooth-row, 5·6 to 6; of mandibular tooth-row, 5·4 to 5·8.

History:—Specimens of this mouse were taken by Drane at Skomer Island in June 1897. He saw at once that his captures differed from *glareolus*, being much larger and having distinct teeth ("A Pilgrimage to Golgotha," in *Rep. and Trans. Cardiff Nat. Soc.*, xxxi., 1898-99, 46, 1900). In an account read 15th Dec. 1898 (*Trans. cit.*, xxxiii., 1900-1901, published 1902), of a second visit to Skomer Island in June 1898, Drane added that he felt inclined to regard his mice as representing "a hitherto unnoticed variety." He took every trouble to get his specimens correctly named, and for that purpose he submitted them, both living and dead, to the Linnean Society of London (*Proc.*, June 1899, 63), and to the authorities of the British Museum; but so great was the lack of knowledge at that date that he received no more satisfactory answer than vague suggestions about a "local variety of *glareolus*."

In 1898 I became aware of the existence of the Skomer Bank Mouse. In October of that year Marsden sent me two taken by Mills, to which Mills afterwards added ten more. These remained in my collection until the publication in 1900 of Miller's "Preliminary Revision of the European Red-backed Mice" (*Proc. Wash. Acad. Sci.*, 26th July 1900, 83-109). This suggested a re-examination of the Skomer specimens, with the result that in 1906 I described the new British Mammal and definitely assigned it a place amongst other related forms of neighbouring countries. It is clear that to Drane belongs the honour of discovering this species (see Proger, *Field*, 20th Feb. 1904, 321; Thomas, *Field*, 12th March 1904, 451), but, that, without Miller's paper, Drane's discovery was meaningless and its value could not be recognised.

Status:—*E. skomerensis* belongs to a group of European bank mice, characterised by size larger than that of *glareolus*, and distributed in isolated colonies, on mountains or islands. These are comparable to the two continental forms of *Lepus timidus*, and may logically be treated as sub-species of one central form, *E. nageri* (Schinz, 1845). The meaning of this group is shown by Hinton's determination of a closely allied form or forms from the late Pleistocene of Ightham, Kent; Brixham, Devonshire; and St Lawrence, Isle of Wight. This palæontological evidence and the characters of *skomerensis* indicate that the latter is a somewhat modified survivor from an older fauna, which has been everywhere driven out by the newer and more recent arrival, *glareolus;* the remains of this last occur for the first time in Britain in the Pleistocene of Ightham, alongside those of the then existing member of the older group. The reality of the group is not invalidated by the fact that one of its forms, *E. nageri*, intergrades with *E. glareolus* through the sub-species *E. n. helveticus*. The large and small forms still remain distinct in origin. As in the case of *Lepus*, isolated members of the group have become so far differentiated as to have attained specific rank; and indeed it is only a matter of convenience whether such geographically isolated forms as *norvegicus* and *nageri* be given the superior or the inferior grade. The following are the known forms, excluding *E. alstoni* and *E. erica* of Scotland, described below:—

E. nageri norvegicus (Miller) of western Norway, and north at least to Nordland, has a broad mantle not sharply defined from the buffy-grey flanks, the hind foot 18·4 to 19, a heavily built skull, the condylo-basal length of which is 24·2 to 26·2 mm., and m^3 has usually three internal infolds. *E. n. vasconiæ* (Miller), of the French side of the Pyrenees, is very similar to the last, but perhaps larger, and with a duller, narrower mantle and less buffy sides. *E. n. nageri* (Schinz) of the Alps and the northern Italian mountains, is slightly larger than *E. n. norvegicus* (hind foot, 18·8 to 20; condylo-basal length of skull, 25 to 26·2 mm.), and has a narrow dark mantle moderately in contrast with the dull greyish flanks. *E. n. hallucalis* (Thomas), of the Aspromonte Mountains and Monte Pellino, southern Italy (Basilicata and Calabria), is a well-marked form, closely resembling *E. n. nageri* externally, but with a longer, narrower brain-case, shorter rostrum, short wide incisive foramina, and larger teeth. Miller's *E. cæsarius* (*Ann. and Mag. Nat. Hist.*, February 1908, 194), first taken by me at St Helier, Jersey, has rich dark colour, short tail and ears, and very large and massive skull; the head and body averages 111, tail 51, hind foot 19·3, ear 11·4, and condylo-basal length of skull 25 to 27·4.

Origin:—There can be no doubt that the Skomer Mouse is the descendant of ancestors formerly inhabiting a region extending at least from Raasay Island, Scotland, to Skomer Island and Jersey. As stated above, they have been driven out by *glareolus*, and isolation has produced local differentiation, so that there are now four known forms, of which *skomerensis* and *cæsarius* are more distinct than the representatives of the same stock inhabiting the mountainous regions of western Europe. The recent discovery of the Scottish members of the group remarkably fulfils Stejneger's prophecy (*Smiths. Misc. Coll.*, 4th May 1907, 478) that he "would not be surprised if they also were to be found in the northern highland of Scotland."

Very little is known about the **habits** of this mouse. Mr Robert Drane always took it about or inside farm buildings, and Dr Y. H. Mills in the heaps of swedes in which it was feeding. Mr Drane kept five alive, and these soon became tame, and increased to forty-seven between June and October. He mentions a litter of five.

ALSTON'S BANK MOUSE.

EVOTOMYS ALSTONI, Barrett-Hamilton and Hinton.

1913. EVOTOMYS ALSTONI, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool. Soc.* (London), No. 119, 15th April 1913, 18; and *Proc. Soc. cit.*, 1913, 827; described from Mull, Scotland (type specimen No. 14.1.30.4 of British Museum collection).

Distribution:—This mouse is at present known only from the Island of Mull, Scotland, where five specimens were taken by R. W. Sheppard in June 1912, during a trip managed by Ogilvie-Grant and financed by many subscribers.[1]

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[1] This first attempt at systematic examination of the mammals of the western islands of Scotland, carried on, in spite of many difficulties, under the superintendence of Ogilvie-Grant, by R. W. Sheppard in 1912, and by D. Anderson, P. D. Montague, and C. H. B. Grant in 1913, resulted in the discovery of one new species of Shrew (*Sorex grantii*), two new species of Evotomys (*E. alstoni* and *erica*); and three new sub-species of the Northern Grass-Mouse, *Microtus agrestis*

Description:—It is a quite distinct form of comparatively large size, but with relatively short ears and tail, and peculiar skull.

In general **size** it approaches *norvegicus*, being larger than *glareolus* but smaller than *skomerensis*. The tail and ears are about as in *glareolus*, the hind feet about as in *norvegicus* or *skomerensis*.

The **colour** is similar to that of adults of the deeply-tinted forms of *glareolus*, being deep "russet" above, the under-side richly washed with yellowish or buffy tints.

The **skull** is larger than in *glareolus*, and agrees in size with that of *norvegicus*, as it does also in the heavy jugals, although the curvature of the zygomata is similar to that of *glareolus*. The brain-case is very broad and smoothly convex, the temporal ridges being but faintly indicated even in aged skulls, and the parietal region in dorsal profile is not flattened but convex, with the highest point a little behind the middle of the parietals; these features impart an appearance of relatively greater cranial capacity than is seen in any other European species of *Evotomys*. The squamosal post-orbital processes are not conspicuous. The inter-orbital region is broad, with a wide shallow median sulcus. The nasals are rounded or slightly and narrowly emarginate behind; they end flush with or slightly behind the ends of the premaxillaries, and are slightly longer than the diastema; they are

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
1. Male, aged, Mull, Scotland (R. W. Sheppard), 18th June 1912 (type) .	108	44	18	11
2. Male, ditto	110	44	19·5	11·5
3. Male, ditto, 19th June 1912 . .	103	44	18	11
4. Female, ditto, 13th June 1912 . .	105	45	18·5	11·5
5. Female, ditto, 14th June 1912 .	100	42	18	10
Average of five adult specimens of both sexes	105·2	43·8	18·4	11

macgillivraii, *M. a. mial*, and *M. a. luch*); in all, of six new forms. The work resulted in very material additions to our knowledge of the distribution of British mammals, and, in particular, of the relationships and classifications of the difficult subfamily of *Microtinæ*, and has thrown much light on the origin of the recent British fauna. The collections made included 280 specimens of 11 species, and have been described by myself and Hinton in *Proc. Zool. Soc.* (London), 1913, 821; and *Ann. Mag. Nat. Hist.*, October 1913, 361; a further paper is in contemplation.

It may safely be said that no collection of British mammals has ever approached the present one in importance.

expanded in front, with their lateral borders slightly but distinctly concave. The rostrum is shallow, as in *E. norvegicus*, its least depth behind the incisors not exceeding its anterior width. The auditory bullæ are about as in *norvegicus*. m^3 has a third inner infold and a fourth inner salient angle, the latter usually well developed.

Skull:—Length, condylo-basal, 24·1 to 25·3; of nasals, 6·8 to 7·8; of diastema, 6·3 to 7·7; of mandible, 15·1 to 15·7; of maxillary tooth-row, 5·2 to 5·7; of mandibular tooth-row, 5·1 to 5·4; breadth, zygomatic, 13·5 to 14·5; inter-orbital, 3·8 to 4·1; occipital, 11·4 to 12·1; depth, median occipital, 6·0 to 6·6.

Status:—Alston's Bank Mouse is, like *E. skomerensis*, probably a relict of an ancestral form of large size which occupied Britain before the arrival of *glareolus*. Being allied to *E. nageri norvegicus* of Skandinavia, it is the latest link in the chain connecting the mammals of Scotland and Skandinavia, and its existence is apparently another indication of a comparatively recent land-connection between the two countries.

THE RAASAY BANK MOUSE.

EVOTOMYS ERICA, Barrett-Hamilton and Hinton.

1913. EVOTOMYS ERICA, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 361; described from Raasay, near Skye, Scotland; type specimen, No. 14.1.30.5 of British Museum collection.

Distribution and History:—This mouse was discovered on the island of Raasay in April 1913 by Montague (see footnote, p. 422 *supra*), who found it rather scarce; his three specimens were "trapped in big heather."

Description: — It resembles *E. alstoni* in general appearance and colour, but is slightly larger, has a more robust tail, and the ventral surface much more heavily washed with buff, in sharp contrast with the dark brown of the flanks and upper surface of the tail.

The **skull** is distinguished from that of *E. alstoni* by its much larger cheek-teeth, broader zygomatic arches, heavier jugals, more salient and extensive post-orbital crests, flatter parietals, narrower inter-pterygoid space, wider pterygoid fossæ, vertical instead of ventrally divergent pterygoids, and auditory bullæ with their antero-internal parts produced inwards as blunt points instead of being rounded. The mandible differs principally in its larger size, and in having the lower borders of the angular processes widened into broad surfaces for the insertion of the superficial parts of the masseter muscles: the width of these muscular facets is 1·4 mm. as against 0·4 mm. in *E. alstoni*.

The **teeth** are of normal form, differing from those of *alstoni* merely in their larger size. As in the latter species, m^3 has a deep third inner fold, and usually a large salient fourth inner angle.

Dimensions in millimetres:—Collector's measurements of three adult but not old males: head and body, 110 (type), 112, 114; tail, 45, 48, 50; hind foot, 18, 20, 20; ear, 13, 14·5, 14.

Skull:—(two males, Nos. 79 (type) and 81), condylo-basal length, 25·2, 25·4; breadth, zygomatic, 14·7, 15; least inter-orbital, 3·7, 3·8; mastoid, 11·8, 11·9; occipital depth, 6·4, 6·6; length of nasals, 7·1, 7·4; of diastema, 6·7, 6·7; of maxillary tooth-row, 6·2, 6·3; of mandible, 16·1, 16·4; of mandibular tooth-row, 6·1, 6·1.

Status:—Like its near relative, *E. alstoni*, the Raasay Bank Mouse seems to be another member of the so-called "Boreal" group of species, surviving in an island, because of the immunity from competition which it there enjoys. Unlike *E. alstoni*, but in this respect resembling *skomerensis* and *cæsarius*, it has undergone considerable specialisation, apparently to fit it for subsistence upon a coarser, and probably a more exclusively vegetarian, diet. It has developed relatively large cheek-teeth, requiring more powerful muscles to move the jaws. The strengthening of the muscles has, in turn, caused those parts of the skull and mandible to which they are attached to grow stronger, and in this way the many differential characters of the skull noted above appear to have been brought into existence. The muscles affected by the enlargement of the teeth are the temporals, masseters, and pterygoids, and every one of the cranial features described is correlated with the increased development of one or other of them.

GENUS MICROTUS.

This genus includes the typical Microtines, which generally but not invariably differ from the members of the genus *Evotomys* in their shorter ears and tail, and in the dull brownish tints of their dorsal surface.

They are first known from the late **Pliocene** of Europe, three or four species having been described from the British Upper Freshwater Bed of Cromer. They appear also in the early Pleistocene of Greenhithe, Kent (Hinton), and in most deposits of later dates, as at Grays Thurrock (*M. agrestoides*, Hinton, *Proc. Geol. Assoc.*, 3rd June 1910, 493, a form characterised by the presence of a fourth exterior angle in m^3), and Ilford, Essex. Some of the early species appear to belong to the sub-genus *Chionomys*. In North America the genus is not known earlier than the Pleistocene.

Although still imperfectly known, the genus includes a bewildering number of species, which, with their sub-species, probably outnumber all other members of the sub-family united. These are widely **distributed** in boreal and transitional, less frequently in arctic or subtropical zones, from ocean to ocean in North America, with Newfoundland, and south to southern Mexico; in Eurasia from the Outer Hebrides to Kamchatka; and south to Portugal, Central Spain, the Mediterranean coasts of France, Northern Italy, the central portions of the Balkan Peninsula, Asia Minor, Northern India, and the island of Kiushiu, Japan.

The genus probably **originated** in Asia and crossed to North America by the Bering Sea route, leaving traces of its presence in St Lawrence (*M. innuitus* of Merriam); St Matthew and Hall Islands, Bering Sea (*M. abbreviatus* of Miller).

The genus having been subdivided, its **characters** may be given under the sub-genera.

SUB-GENUS MICROTUS.

1798. *Microtus*, F. v. P. Schrank, *Fauna Boica*, 1, 72, based on *Microtus terrestris* of Schrank=*Mus arvalis* of Pallas; Lataste, *Le Naturaliste*, 15th October 1883, 348 (sub-genus); Miller, *N. Amer. Fauna*, No. xii., 23rd July 1896, 62; and *Catalogue*, 1912.

Synonymy:—Owing to difficulties of identification and classification, the synonymy is long and complicated; but, since the segregation of the Water Rats in the genus *Arvicola*, a name formerly used to include all "voles," there can be no doubt as to the use of the name *Microtus* for the present genus. The full synonymy may be found in Miller's *Catalogue*.

These mice are sedentary grass-feeders of much narrower habits than the Bank Mice. They are neither climbers nor specially modified for a subterranean existence, in either fur, which is never dense or mole-like, or claws, which are slightly larger on the hind feet. The soles are moderately hairy, and there are six plantar pads, of which one may be rudimentary.

The **mammæ** are eight, as in *Evotomys*.

The **skull** is ridged and angular; the inter-orbital region narrow; the temporal ridges well developed. The bony palate (Fig. 60, B, p. 401) terminates posteriorly in a median ridge sloping dorsally between two lateral pits; this ridge becomes narrower and more abrupt with age; it may sometimes encroach on the anterior edge of the inter-pterygoid fossa, or it may be slightly cleft centrally.

In the **teeth** the root of each lower incisor crosses the tooth-row to the labial side between m_2 and m_3, displacing the latter tooth and forming a more or less distinct protuberance on the outer surface of the condylar process of the mandible.

The cheek-teeth are permanently rootless; growing continuously from a persistent pulp, they do not wear away with age. Their enamel-pattern is characterised by the substantial closure of all triangles in adult stages of wear, by acute salient angles, and by the large number of salient angles in m^3 and m_1. m^3 usually consists of an anterior transverse loop succeeded by three closed triangles, two smaller on the outer and a larger on the inner side, followed by a posterior loop of variable shape. There are at least seven salient angles (four on the inner side), two formed by the anterior transverse loop, one by each of the three closed triangular spaces, and two by the posterior loop.

In m_1 there are usually a posterior transverse loop; five closed triangles—two on the outer and three on the inner side; and an anterior loop, usually more or less deeply cut by an inner and an outer fold, the latter always posterior to the former. There are in normal species seven infolds and at least nine salient angles; two of the latter are formed by the posterior transverse loop, one by each of the five closed triangles, and one by each side of the base of the anterior loop.

Variations from the normal enamel-pattern of the genus occur constantly, and characterise the dentition of several species; in addition there may exist in any species variations of a purely individual nature, often due to varying stages of tooth-wear. In m^3 the first outer triangle may open into the large inner, or less frequently into the anterior loop. The second outer triangle may rarely open into the inner, but rather frequently communicates with the posterior loop. The posterior loop is of quite variable shape. In m_1 there may be a sixth, occasionally a seventh, closed triangle, in each case cut off from a much reduced anterior loop. Sometimes the fourth inner fold (counting from behind) fails to meet the third outer; or the anterior loop is complicated by the development of one or more additional salient angles and infolds on either side anteriorly.

The British species and sub-species are as given below. They fall into two groups:—

1. *Agrestis* group.
    - (1) *M. agrestis macgillivraii*, of Islay.
    - (2) *M. agrestis exsul*, of the Outer and Inner Hebrides.
    - (3) *M. agrestis mial*, of Eigg.
    - (4) *M. agrestis neglectus*, of the Scottish Highlands.
    - (5) *M. agrestis luch*, of Muck.
    - (6) *M. hirtus hirtus*, of Britain south of the Highlands.
2. *Orcadensis* group.
    - (7) *M. orcadensis ronaldshaiensis*, of South Ronaldshay.
    - (8) *M. orcadensis orcadensis*, of Pomona.
    - (9) *M. orcadensis rousaiensis*, of Rousay.
    - (10) *M. orcadensis westræ*, of Westray.
    - (11) *M. orcadensis sandayensis*, of Sanday.

Much new material has been received only since the publication of the earlier pages on *Microtinæ*, and therefore two sub-species of *agrestis*—*mial* and *luch*—and two of *orcadensis*—*ronaldshaiensis* and *rousaiensis*—could not be included in the Key to the *Muridæ* on pp. 377-381.

GROUP AGRESTIS.

Miller grades all the west European Grass Mice having an extra prism in m^2 as sub-species of *agrestis*. This method, however, obscures their relationships, especially the fact that, as in *Evotomys*, a newer, smaller form, *M. hirtus*, has replaced an older, larger, *M. agrestis*, the latter now confined chiefly to northern regions, and with isolated southern colonies on mountains. These two forms are of entirely distinct origin, and are here given specific rank, and each has sub-species. Like *Lepus timidus*, *Evotomys skomerensis*, *alstoni*, and *erica*, *M. agrestis* belongs to an older fauna; *M. hirtus* to that of *Lepus* (*Eulagos*) *europæus* and *Evotomys glareolus*.

This division of Linnæus's *agrestis* into two forms has long been known, as to de Sélys in 1841. Although its meaning was not recognised, it was discussed by Blasius in 1857, and by myself in 1896. The scanty material available, and the lack of knowledge of the synonymy, structure, and geological history of the various forms long militated against a satisfactory use of the facts.

The *agrestis* group ranges right across northern Asia, at least to North-western Mongolia (*M. a. mongol* of Thomas) and Dzungaria (*M. arcturus* of Thomas).

In America it is represented by several allied but distinct forms which occupy the whole continent in subarctic, boreal and transitional zones, from Alaska to Labrador and Newfoundland.

The group is thus quite comparable to others of circumpolar distribution. As it avoids the extreme north, it has no species common to the Old and New Worlds. *M. pennsylvanicus* (Ord) of the eastern United States is so closely allied to *M. agrestis* in skull and teeth, that it has been used as an argument for a recent Atlantic land-bridge (Scharff); but it is quite distinct in colour in a group where all the forms are closely allied.

THE NORTHERN GRASS MOUSE.

MICROTUS AGRESTIS (Linnæus).

1761. MUS AGRESTIS (species), Carolus Linnæus, *Fauna Suecica*, ed. ii., 11, No. 30; described from Upsala, Sweden (from the *Mus agrestis minor* of Gesner).

1766. MUS GREGARIUS (species), Carolus Linnæus, *Systema Naturæ*, xii., 84; described from Germany and Sweden.

1857. ARVICOLA AGRESTIS (a.), J. H. Blasius, *Säugethiere Deutschlands*, 369 (part).

Markmus of the Norwegians; not known to the French or Germans.

This abbreviated **synonymy** is that of the species *agrestis*, the technical name of which admits of no doubt; since the typical subspecies is not found in Britain, there is no need for detail, which may be found in Miller's *Catalogue*. That of the five British sub-species is given at length under each. As in the case of other animals (*e.g.*, bats, shrews, and hares), there was formerly some doubt as to the identity of *agrestis*, owing to the presence of a second species, *arvalis*, which, although abundant in many parts of Europe, is not known in Skandinavia.

Distribution:—The Northern Grass Mouse ranges from the Outer Hebrides, Scotland, and Skandinavia, at least to North-western Mongolia, where the local form, *M. a. mongol* of Thomas, can only be distinguished from true *agrestis* by its larger bullæ; there is also an isolated colony—*M. a. levernedii* (Crespon)—inhabiting the Alps, Jura, and neighbouring portions of Switzerland and France, with the marshes at the mouth of the Rhone on the Mediterranean coast of France. Although completely isolated geographically, *levernedii* is not well differentiated from *M. a. agrestis* of Skandinavia, and can only be distinguished by its longer and narrower skull, in which the distance from the condyles to the back of the inter-orbital constriction is usually greater than the zygomatic breadth, whereas in *M. a. agrestis* these two dimensions are usually about equal. *M. a. agrestis* is, in Skandinavia, chiefly, but not entirely, a lowland form; it is one of the most numerous mammals of Norway, being found on the cultivated islands and ranging to the extreme north of the country at Lebesby (Collett).

In **Britain** it is confined to the Highlands of Scotland and the western Scottish islands (but notably absent from Lewis), where it occurs in five sub-specific forms.

Distribution in time:—The species first appears in Britain in the late pleistocene deposits of Ightham, Kent (see under *M. a. neglectus*).

Description:—*M. agrestis* may be known amongst European species by its moderate size (hind foot, 18 to 21; condylo-basal length of skull in adults, 25 to 28·7 mm.), and especially by its m^2, which has a well-developed postero-internal triangle forming a third inner angle.

In **form** and **appearance**, in which it is typical of its genus, it differs chiefly from *Evotomys* in its more robust, thicker build, less conspicuous ears, shorter tail, and duller tints.

The evenly rounded **ears** are hidden in the fur, and when laid forward reach about half-way to the eyes; the meatal lobes are well developed and reach a height centrally of about 3 mm. The small eyes are not prominent; they lie nearer the muzzle than the base of the ears. The tail is about one-third as long as the head and body. The mouth is small.

The **hands** and **feet** resemble those of *Evotomys glareolus*, but the minute thumb is almost concealed dorsally by the relatively large nail, and the hallux does not quite reach the base of digit two.

In the **tail** the annulations are pronounced but slightly irregular, their number about 20 to the cm. centrally; they show through the thin hairs, which, however, form a distinct terminal tuft.

The **skull** is moderately broad, the ratio of zygomatic breadth to condylo-basal length being from 55 to 60; the inter-orbital region develops a distinct ridge in adults; the length of the brain-case measured from the inter-orbital constriction to the condyles is not less than the zygomatic breadth.

In the **teeth** the upper incisors project slightly; the cheek-teeth are moderately large, with sharp salient angles and well-cut folds. In the maxillary series m^1 is decidedly the longest, m^2 and m^3 being subequal in crown-length. m^1 and m^2 are composed of the same elements as in *Evotomys*, but possess, the former variably, the latter invariably, a more or less reduced, supplemental postero-internal prism, forming a conspicuous and very distinctive third inner salient angle in m^2.

[European species with this pattern in m^2 have sometimes been placed in a sub-genus named *Agricola* or *Sylvicola*.]

m^3 begins with the usual transverse loop and three closed triangles; its posterior loop is long, and cleft internally by a deep fold, so that in the simplest form the tooth terminates in a strongly crescentic formation; it possesses three infolds with four salient angles on each side, of which the postero-external is weak and frequently obsolete. In a more complicated and rarer form the posterior inner fold extends across the loop to its outer side, thus isolating a second inner closed triangle followed by a simple posterior loop, which sometimes bears an incipient internal fold.

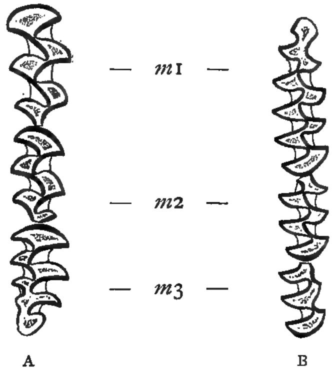

FIG. 65.—RIGHT CHEEK-TEETH OF *Microtus agrestis* (A, upper; B, lower: 7 times life size.)

In m_1 the large anterior loop is cleft by a deep internal and, more posteriorly, by a shallower external re-entrant angle. This gives the tooth two anterior rounded projections, and behind them two shallow folds, in addition to the usual well-defined nine salient angles and seven infolds. Sometimes the shallow folds of the anterior loop may be deep enough to isolate a third outer triangle, so that the loop becomes a crescent resembling that of m^3 and a rudimentary sixth inner fold appears; rarely there may be a supplemental fold on the extreme antero-external border. (See Fig. 65.)

m_2 is of the usual type, but as an abnormality its anterior external triangle may develop a slight inner basal projection so as to produce a small additional inner salient angle. In m_3 the salient angles and folds are bilaterally very unequal, being much deeper on the inner side, and with the antero-external angle usually obsolete.

Geographical variation:—There are seven more or less differentiated sub-species. Two have been described above under *Distribution*. The other five are British.

Status:—The arrival of a newer and more vigorous competitor in

M. hirtus is sufficient to account for the present restriction of the older *agrestis* to islands, mountains, and northern regions, where the competition is only moderately severe. In addition, the larger and extremely palatable forms of *Microtus* probably find a difficulty, like the lemmings, in escaping from their enemies in the absence of moderately heavy snow. They thus survive only where carnivora are scarce, or where the coarse herbage both feeds and protects them. This coarse herbage has no attractions for the newer dominant species, which prefer the richer diet more easily obtainable in warmer or more cultivated districts.

The British sub-species are as follows:—

MACGILLIVRAY'S GRASS MOUSE.

MICROTUS AGRESTIS MACGILLIVRAII, Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS MACGILLIVRAII, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool Soc.*, London, No. 119, 15th April, 18, and *Proc. Zool. Soc.*, London, 1913, 831; described from Islay, Scotland; type specimen, No. 14 1.30.1 of British Museum collection.

Distribution and History:—This Grass Mouse appears to be confined to Islay, where the existence of a "vole" seems to have been first reported by T. F. Gilmour, who sent one found dead on 30th July 1905 to the editors of the *Ann. Scott. Nat. Hist.* (1905, 242). An immature specimen from Kildalton, too young for determination, was submitted by Kinnear to Miller (*Ann. and Mag. Nat. Hist.*, February 1908, 201); and three young found in a rick were forwarded to Thomas by Russell (*Zoologist*, 1910, 115), who did not think the animal common. A series of fourteen caught by Sheppard in the woods around Bridgend at once showed the distinctness of this mouse, which might well be called a species were it not that the sub-specific name indicates its relationships. Sheppard visited the island twice, and reported after his first visit that the animal was very scarce, as he was only successful in finding two colonies—one in a small belt of hazel, known as Dale Bush, the other in a walled graveyard about two miles south of Port Ellen, on the border of the district known as the Oa. On his second visit he found grass mice, shrews, and field mice all using the same runs in open ground overgrown with brambles, raspberries, and coarse grass.

Description:—MacGillivray's Grass Mouse resembles the more widely distributed *M. a. exsul* (next to be described) in size and general proportions, but may be recognised at all seasons by its much thinner coat (length of dorsal hairs reaching about 8 mm.) and duller coloration, especially on the under-side. The skull also shows some peculiar characters, as described below.

Colour:—The upper side is rich "buff," of a slightly duller tint than in *M. a. exsul;* the under-side is almost devoid of the yellowish wash often so conspicuous in that form, and, owing to the thin pelage, the slaty hair-bases are frequently visible and take part in the general coloration.

The **young** have a dusky pelage in which there is very slight development of the light dorsal hair-tips. Those of the under-side are of a very light tint, increasing in depth towards the flanks and poll, where they are deepest, but never approaching the rich tints of adults; the dusky rump is in contrast to the back.

The **skull** (as compared with that of *M. a. exsul*) is distinguished by its deeper rostrum, lighter jugals, and more nearly vertical occiput; in correlation with the latter the interparietal is longer antero-posteriorly and has the posterior border straight instead of sinuous. Still more characteristic is the course of the temporal ridges on the anterior part of the brain-case, since they are never pushed backwards to the extent accruing in *exsul*, in aged specimens of which they are constricted anteriorly; the shape of the "shield" delimited by these ridges is therefore very different in the two forms (Fig. 66, 2 and 3).

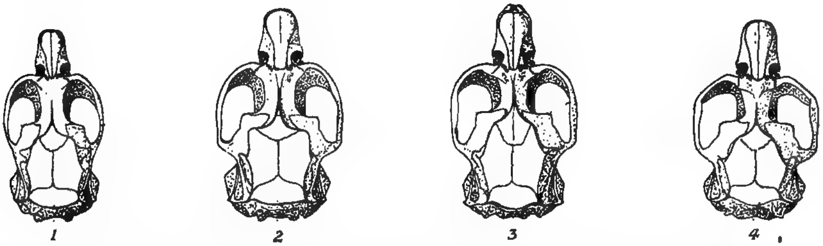

FIG. 66.—DORSAL VIEWS OF ADULT SKULLS OF *Microtus agrestis* GROUP.
1. *M. hirtus hirtus.* 2. *M. a. macgillivraii.* 3. *M. a. exsul.* 4. *M. a. neglectus.*
Natural size. (Drawn by M. A. C. Hinton.)

The **teeth** agree with those of *exsul; m*^{1} (in eight skulls examined) has constantly a fourth inner angle behind, and this feature is sometimes largely developed.

Dimensions in millimetres:—Adult males (type, and two other old specimens): head and body, 125; tail, 32, 37, 40; hind foot, 19; ear, —, 15, 12. Adolescent: head and body, 115; tail, 34; hind foot, 19; ear, 12. Young: head and body, 90; tail, 27; hind foot, 18; ear, 10.

Skull:—Condylo-basal length, 26·4 to 28·7; breadth, zygomatic, 15·3 to 16·4; least inter-orbital, 3·6 to 3·8; mastoid, 11·8 to 12·6; occipital depth (median), 6·2 to 6·7; length of nasals, 7·6 to 8·7; of diastema, 7·2 to 7·8; of maxillary tooth-row, 6·6 to 7·1; of mandible, 16·2 to 17·6; of mandibular tooth-row, 6·3 to 6·7. (Except the least inter-orbital breadth, which decreases with age, the minimum values are those of immature, the maximum those of adult skulls, the subadults ranging between these extremes.)

Status:—This mouse, like the shrew and stoat of the island, is peculiar to Islay, which has evidently long been separated from the other islands and the mainland of Scotland. MacGillivray's Grass Mouse is slightly more primitive in pelage and skull than the other forms of *M. agrestis*, and so may be regarded as an insular survival rather than as a new development.

THE HEBRIDEAN GRASS MOUSE.

MICROTUS AGRESTIS EXSUL, Miller.

1908. MICROTUS AGRESTIS EXSUL, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 201 ; described from North Uist, Outer Hebrides ; type specimen, No. 6.3.1.3 of British Museum collection ; Trouessart ; Miller (*Catalogue*).

1909. MICROTUS AGRESTIS INSUL, R. Lydekker, *Zool. Record*, 1908, xlv., *Mamm.*, 74 ; accidental renaming of *exsul*.

History:—The occurrence of Grass Mice in the Inner Hebrides has long been known, but, with those of Orkney and the mainland, they have generally been lumped together as representing one widely distributed species. From South Uist they were first reported to Harvie-Brown by M'Donald of Rodil and Henderson of Loch Boisdale, and in 1879 Harvie-Brown himself captured a specimen at Newton, North Uist. The relationships of the Outer Hebridean form were, however, not recognised until Miller began his work for his *Catalogue*; his description of *exsul* was based on fourteen examples from North and South Uist, all of which except three had been taken by Kinnear, who supplied the first properly prepared specimens of this form. The presence of "voles" on other Scottish islands was also long known, having been mentioned by Alston in 1880; but, in the absence of systematic collecting, they could not be submitted to accurate study until the receipt of Sheppard's specimens in 1912. (See footnote on p. 422 *supra*.)

Distribution:—This is the Grass Mouse of the Hebrides generally, where it has thus far been found, often in abundance, on Arran (common, Alston), Gigha, Jura, Mull, Skye, North and South Uist, and Benbecula. In Jura it is sometimes so numerous as to be a danger to young plantations (Henry Evans, *in lit.*, 11th February 1900). It probably occurs also in other islands, as Rum (Millais). It is absent from Lewis (Duns, 1865, 620, and later writers), but there are distinct forms in Islay, Eigg, Muck, and Bute.

Description:—This large Grass Mouse differs from the Skandinavian *M. a. agrestis* only in the frequent presence of a small posterior fourth inner angle in m^1. From the Common Grass Mouse it may be distinguished by its much larger size and duller brown colour. From *M. a. macgillivraii* it differs in its slightly brighter colour, thicker pelage, and in the skull characters as already described above on p. 433.

The **fur** is soft and thick, the longer hairs of the back reaching a length of about 15 mm. in winter and the ordinary hairs about 12 mm., of which their light-coloured tips amount to about 2-3 mm.

The **colour** of the upper side is a clear brown, somewhere between "bister" and "ochraceous buff," yellower on the sides. The longer hairs are shiny black; the under-fur has tips 2 mm. long of dull—between ochraceous and cream—buff, the extreme tips often dusky. The under-side and feet are rather heavily washed with brownish, often light ochraceous, buff. The tail is bicoloured, especially in winter, when all the colours are lighter.

The **skull** is large and in old individuals strongly angular, developing a knife-like ridge in the inter-orbital region. The brain-case is short, the distance from the back of the inter-orbital constriction to the posterior surfaces of the condyles being barely equal to the zygomatic breadth. In old skulls the "shield" between the temporal ridges is considerably narrower anteriorly between its antero-external angles than at the level of the glenoid articulation (Fig. 66, 3).

In the **teeth** a small posterior fourth inner angle is usually present in *m*¹, having been found by Miller in ten out of fourteen skulls examined, by Hinton and myself in twenty out of twenty-one skulls;[1] in other sub-species this formation is very rare, being present in only eight amongst one hundred and thirty-six skulls.

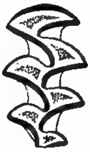

FIG. 67.—RIGHT *m*¹ OF *Microtus agrestis exsul.*

Dimensions in millimetres (from actual specimens):—Old adult, 125—36—19—12; adolescent, 115—32—18—12; immature, 100—30—18—11; youngest examined, 60—15·5—14—5·5. The tail ranges in subadult to old specimens from 28 to 49. Females are found pregnant or nursing when they attain 109, before assuming adult pelage.

Skull:—Condylo-basal length, 26·5 to 28·6; breadth, zygomatic, 14·6 to 16·5; least inter-orbital, 3·2 to 3·5; mastoid, 11·6 to 12·5; occipital depth (median), 6·2 to 7·1; length of nasals, 6·8 to 8·4; of diastema, 7·4 to 8·1; of maxillary tooth-row, 6·5 to 7·0; of mandible, 16·5 to 18·0; of mandibular tooth-row, 6·4 to 7·0. (Except the least inter-orbital breadth, which decreases with age, the minimum values are those of immature, the maximum those of adult skulls, the subadults ranging between these extremes.)

Status:—This mouse is a moderately differentiated sub-species of the Skandinavian Grass Mouse, from which, as stated above, it can only be distinguished by a peculiarity of the enamel-pattern, occurring as a normal feature, instead of, as in other members of the group, as a rather rare anomaly. If, however, a Scottish origin for the Skandinavian *Microtus agrestis* be accepted, the sub-species *exsul* is then geographically the more primitive, and it is quite natural to find the newer forms exhibiting a simpler and less primitive dentition. It is also natural to find *exsul* more closely related to the true *agrestis* of Skandinavia than are either *macgillivraii* or *neglectus.* None of these large forms are especially closely related to *hirtus* of England.

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[1] Small but distinct in nine; recognisable microscopically in eleven; entirely absent in one. This loop is also found occasionally in the North American *M. pennsylvanicus* (Ord), as figured by Miller, *N. Amer. Fauna*, No. 12, 23rd July 1896, fig. i. I have also figured it as an abnormality in *M. a. agrestis* (*Proc. Zool. Soc.*, London, 1896, 598).

The **habits** are not known to differ from those of other Grass Mice. In Arran Mr R. W. Sheppard found the mice living mostly in scattered colonies on the edges of sheltered woods and young plantations of conifers on the north side of Brodick Bay; he met with no trace of them in the country around Blackwater foot. In Jura they frequented open pastures and had also runs through clumps of coarse grass at the edges of woods. In Mull they had scattered colonies on the cliffs above Tobermory on the western sides, at Croggan in open glades on hill-sides in natural woods, and on a hill at Buncosan, but were very scarce in all three localities.

In North and South Uist they are extremely abundant all over the hills, and in the sandy meadows or machars; in some localities they make a network of runs in the grass. Mr N. B. Kinnear has supplied sketches (Fig. 68) of the sleeping-places as found in small mounds in North Uist. These blind, somewhat circular, terminals to the burrows were always of the same shape and had their sides smooth, as if much used; they contained no grass or moss.

They seem to perform a seasonal migration, being most abundant in autumn on the lower grounds and near farms, while in summer they are distributed all over the uninhabited districts.

In North Uist Mr J. G. Millais has seen the collie dogs hunting them all day long, when not actually engaged in work, and a collie once stuffed himself so full of them that he was sick.[1]

They are hardy and do not hibernate [I have seen Skandinavian specimens of *agrestis* taken in a forest with 2 feet of snow on the ground].

The habits of the Norwegian form are given with much interesting detail by Robert Collett, but cannot be quoted here. It is evident that in northern countries of heavy snowfall, the habits are quite distinct in many respects from those prevalent in more southern districts. Nowhere, however, is there any hibernation, the mice being, like lemmings, active under the snow in winter.

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[1] See p. 432 *supra.* Cocks (in Norway) had a setter very nearly die from bolting lemmings wholesale.

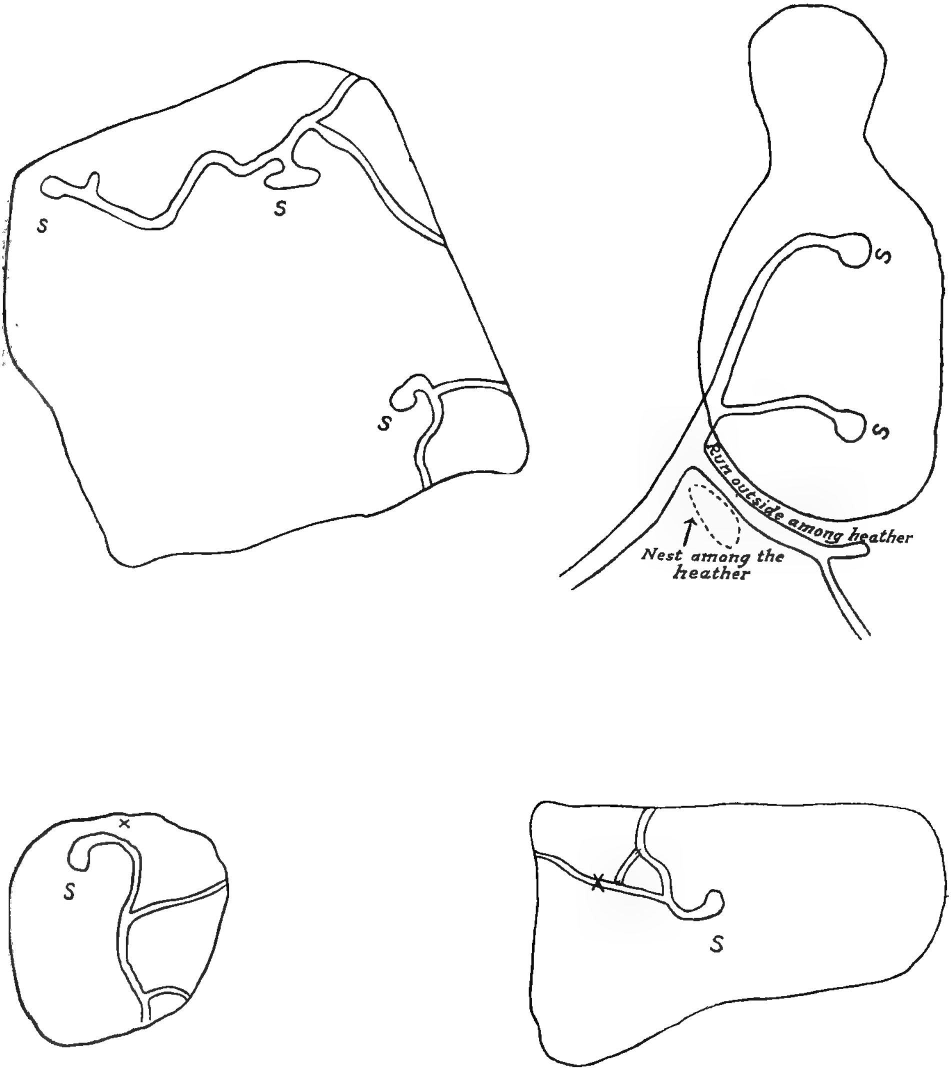
S
S
S
S
S
Run outside among heather
Nest among the heather
×
S
X
S

Fig. 68.—Sleeping-places of *M. agrestis exsul* in Small Mounds. (Sketched by N. B. Kinnear.)
S = Sleeping chamber; *X* = Patch of droppings.

THE EIGG GRASS MOUSE.

MICROTUS AGRESTIS MIAL,[1] Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS MIAL, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 364; described from Eigg, Scotland; type specimen, No. 14.1.30.3 of British Museum collection.

Distribution and History:—This mouse is at present only known from the island of Eigg, where it was first taken by Montague in March and April, and by Anderson in June 1913 (see footnote on p. 422 *supra*). Millais had previously suspected the occurrence of Grass Mice on Eigg.

Description:—*M. a. mial* agrees generally in size and proportions with *M. a. exsul*, but differs strikingly in pelage. The fur is longer and rather coarser in texture, so that the animal has a shaggy instead of a sleek appearance. This is due in great measure to the abundance and length of the long dusky hairs, which tend to darken the rump and flanks, leaving the general **colour** of the back very much as in *exsul*. The under-sides and the posterior surfaces of the hind legs are silvery in sharp contrast with the dark brown flanks; rarely the underside shows faint traces of a median stripe of yellowish wash.

The **skull** differs from that of *exsul* of equal age in having the nasals and basioccipital relatively a little shorter, and the auditory bullæ slightly smaller.

The **teeth** are as in *exsul*. Amongst nineteen specimens, the fourth inner angle of m^1 was entirely absent in only one; in three it was represented merely by a microscopic vestige; in eleven it was small but quite distinct; and in four it was large and of regular form.

Dimensions in millimetres:—head and body (young to middle-aged), 98 to 116; tail, 27 to 39; hind foot, 17 to 20; ear, 10 to 13. In the type these items are respectively 113—36—20—12.

Skull:—Condylo-basal length of type (middle-aged), 27·4; breadth: zygomatic, 15·7; inter-orbital, 3·5; mastoid, 11·8; occipital depth, 6·3; length of nasals, 7·2; of diastema, 7·8; of maxillary tooth-row, 6·4; of mandible, 17·9; of mandibular tooth-row, 6·3.

Status:—This mouse, as is shown most clearly by its dental and cranial characters, has its nearest ally in *M. a. exsul*. It may be regarded as a peripheral and local development of the latter, which has arisen probably as a result of segregation for a long time upon a small island.

Habits:—Montague found this mouse common amongst coarse heather; it is not strictly nocturnal.

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[1] *Mial* in Scotch Gaelic is the general word for beast.

THE HIGHLAND GRASS MOUSE.

MICROTUS AGRESTIS NEGLECTUS (Thompson in Jenyns).

1841. ARVICOLA NEGLECTA, William Thompson in Leonard Jenyns, *Ann. and Mag. Nat. Hist.*, 270, June; described from moors near Megarnie (*sic*), *i.e.*, Meggernie Castle, Perthshire, Scotland.

1857. ARVICOLA AGRESTIS (b.), ARVICOLA NEGLECTA, J. H. Blasius, *Säugethiere Deutschlands*, 369 (part).

1896. MICROTUS AGRESTIS NEGLECTUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 598 and 606 (part); Trouessart (part); Miller, *Catalogue*.

Local names (non-Celtic):—*grass mouse*, *hill mouse*, *meadow mouse*, *water mouse* (the latter *fide* E. R. Alston), i.e., *earth hound* (Taylor).

(Celtic):—*luch-fheoir* or *luch-an fheoir*="grass mouse," is used indiscriminately for all mice in Scotland, as is *fiolagan* in Arran (C. H. Alston).

History:—Although described by Thompson in a paper by Jenyns in 1841, it cannot be said that the original description added anything to knowledge. In fact the name *neglectus*, although first applied to the highland form of true *agrestis*, was actually transferred by de Sélys and many subsequent writers, including myself, to the small southern *hirtus*. The synonymy and relationships are now, however, clear, mainly as the result of the work of Miller and of Hinton in different fields of mammalogy, and of Ogilvie-Grant in organising a collection of Scottish mammals.

Distribution:—This is the Grass Mouse of the Highlands of Scotland, where it is widely distributed and common in all suitable localities to the highest summits of the mountains, as, for instance, around and in the observatory buildings on Ben Nevis at 4400 feet (Bruce, *Ann. Scott. Nat. Hist.*, 1896, 187). It is not definitely known exactly where *neglectus* ends and *hirtus* begins. Service's (*Journ. cit.*, 1903, 68) and W. Evans's remarks on the distinctness of hill and lowland specimens in the Solway and Edinburgh districts suggest that *neglectus* ranges to the hills of south Scotland, and I have seen specimens from Lanarkshire taken by Kinnear. Millais probably alludes to these two forms when he states that, although English specimens vary very little in colour, immediately the Border is crossed, beginning with Wigtownshire and the Cheviots, two very distinct types are found, one larger and greyer on the hills, the other smaller and redder and with thinner coat on the low ground. Millais believes that the distinctions are accentuated as one goes north, but that the succession of "intermediate varieties is so continuous and so well-connected that it is impossible to create a dividing line." The question requires further investigation. *M. a. neglectus* probably occurs on the coastal islands, having been taken by Sheppard on Bute (see *Proc. Zool. Soc.*, London, 1913, 833), where it occupies marshy ground south of Kilchattan, and the road-sides in the extreme south of the island.

Distribution in time:—According to Hinton, *M. a. neglectus*, or a similar form, appears first in the late pleistocene Fauna of Ightham Fissure, Kent, while *M. hirtus* is only known in more recent times.

Description:—This Grass Mouse is as large[1] as its relatives of the islands, differing from *exsul* chiefly in having, on the average, a simpler m^1; besides being much larger than *M. hirtus* of England it is more heavily furred, and has the upper surface darker and browner. The light bars of the hairs are near "ochraceous buff" approaching tawny, and the resulting colour of the pelage is near "prouts brown," with suggestions of "burnt umber" and "raw umber"; the under-side is some shade of dull grey, or may be lightly washed with yellowish or "wood brown." A male taken by Sheppard on 24th July 1908, was **moulting**.

The **skull** of young adult and middle-aged specimens is larger than that of *M. hirtus*, having a condylo-basal length of 25·4 to 26·6 mm. At this stage it resembles that of *M. a. exsul* of similar size, but has smaller bullæ, as in *M. hirtus*. In old age it attains a condylo-basal length of from 27·5 to 28·1 mm. or more, and the distinction from *M. a. exsul* in respect of the bullæ is less striking.

The **teeth** are of the normal form; m^1 is usually without any trace of the fourth inner angle, but occasionally a vestige of it is present in the larger specimens; it never attains the size sometimes attained in *exsul*.

Dimensions in millimetres:—Immature female, 109—37—18—13; subadult male, 118—42—17·5—12; old male, 128—40—19—16.

Skull:—Condylo-basal length, 25·4 to 28·1; breadth, zygomatic, 14·4 to 16·1; inter-orbital, 3·2 to 3·6; occipital, 11·2 to 12·8; depth, median occipital, 6·2 to 6·9; length of nasals, 7 to 8·1; of diastema, 7·2 to 8; of mandible, 16 to 17·5; of maxillary tooth-row, 6·5 to 7; of mandibular tooth-row, 6·2 to 6·5.

Status:—*M. a. neglectus* is a little less primitive than the Hebridean *exsul* in that its m^1 is slightly more reduced; like *exsul* and the other British sub-species, it is, however, intimately related to the true *agrestis* of Skandinavia. The differences between them appear mainly to be due to a long-continued segregation. The close relationship of these North British and Skandinavian forms is parallel to that of the Varying Hares, of which *Lepus timidus scoticus* agrees closely with *L. t. timidus* of Skandinavia; but there are no Irish Grass Mice to repeat the relationship between *L. hibernicus* and the extinct pleistocene *L. anglicus*.

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[1] Miller and other writers never examined full-grown specimens.

THE MUCK GRASS MOUSE.

MICROTUS AGRESTIS LUCH,[1] Barrett-Hamilton and Hinton.

1913. MICROTUS AGRESTIS LUCH, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, October 1913, 366; described from Muck, Scotland; type specimen, No. 14.1.30.2 of British Museum collection.

Distribution and History:—This Grass Mouse is only known from three specimens taken on the island of Muck by Montague (see footnote on p. 422 *supra*). It was found in short heather on the edge of a cliff, where it appeared to be scarce. Millais had previously suspected the existence of Grass Mice on the island.

Description:—It is a quite distinct form, differing from *exsul* in its smaller size, in which it approaches *hirtus*; agreeing with *mial* in its only slightly less dense and shaggy coat, and with *neglectus* in its skull and teeth; and being quite peculiar in its conspicuously buff under-side. The **colour** of the back is similar to that of *mial*, but owing to the long black hairs becoming fewer and shorter laterally, the flanks are lighter than those of the Eigg form, their colour gradually passing into the heavy buff wash which extends all over the ventral surface of the body and tail. This buff under-side is, however, here and there darkened to a small extent by the slaty bases of the hairs which show through.

The **skull** cannot be distinguished from that of small examples of *neglectus*; it differs quite strikingly from that of *mial* in its smaller size, relatively greater zygomatic breadth, broader brain-case, and longer basioccipital.

The **teeth** of the three specimens examined are normal, m^1 having no trace of a fourth inner angle.

Dimensions in millimetres of, respectively, a fully adult male (type of the sub-species), a male, and an adult female:—head and body, 110, 108, 105; tail, 33, 32, 33; hind foot, 18, 17·5, 18; ear, 11·5, 11, 11.

Skull (of the type):—Condylo-basal length, 26; breadth, zygomatic, 15·5; inter-orbital, 3; mastoid, 11·8; occipital depth, 6·6; length of nasals, 7·2; of diastema, 7·2; of maxillary tooth-row, 6·3; of mandible, 16·8; of mandibular tooth-row, 6·1.

Status:—This mouse must apparently be regarded as a dwarfed insular development of *M. a. neglectus*, the form inhabiting the neighbouring Scottish mainland. The occurrence of an animal with such relationships on Muck is remarkable, because on the closely adjacent Eigg, as on Skye, Mull, Jura, Islay, Gigha, and Arran, the Grass Mice are either identical with *exsul*, or more nearly related to it than to *neglectus*. It would seem from the above facts that Eigg and

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[1] *Luch* in Gaelic means "mouse."

Muck have been for a very long period separated from each other, and that Muck has been in connection with the mainland more recently than most of the other islands.

THE COMMON GRASS MOUSE.

MICROTUS HIRTUS (Bellamy).

MICROTUS HIRTUS HIRTUS (Bellamy).

1769. MUS TERRESTRIS, John Berkenhout, *Outlines of the Natural History of Great Britain and Ireland*, i., 5 (part); not *Mus terrestris* of Linnæus (1758)=*Arvicola terrestris*.

1807. MUS ARVALIS, W. Turton, *British Fauna*, 12 (part); Bingley; Donovan; not *Mus arvalis* of Pallas, 1778.

1828. ARVICOLA AGRESTIS, John Fleming, *A History of British Animals*, 23 (part); Yarrell, *Proc. Zool. Soc.*, London, 1832, 109; Jenyns; Bell, edd. 1 and 2; MacGillivray; de Sélys-Longchamps; Owen; Morris, *Cat. Brit. Foss.*, ed. 2, 1854, 357; Sanford, *Quart. Journ. Geol. Soc.*, xxvi., 1870, 124; Blackmore and Alston; Lydekker, *Cat. Foss. Mamm. Brit. Mus.*, i., 232; Flower and Lydekker; Winge; Lataste, *Le Naturaliste*, 15th October 1883, 349.

1839. ARVICOLA HIRTA, J. C. Bellamy, *Natural History of South Devon*, 373; described from Yealmpton, Devonshire, England.

1841. ARVICOLA ARVALIS, Leonard Jenyns, *Ann. and Mag. Nat. Hist.*, June 1841, 269 (part).

1847. ARVICOLA BRITANNICUS, E. de Sélys-Longchamps, *Revue Zoologique* (Paris), 307, October; described from England and Scotland; also, *Atti della Ottava Riunione degli Sci. Ital.* (Genoa, 1846), 495, 1847.

1857. ARVICOLA AGRESTIS (b.), ARVICOLA NEGLECTA, J. H Blasius, *Säugethiere Deutschlands*, 369 (part)

1883. MICROTUS AGRESTIS, A. Smith Woodward and C. D. Sherborn (part); Lydekker; Barrett-Hamilton, *Proc. Zool. Soc.*, London 1896, 602; Aflalo; Johnston; Thomas, *Zoologist*, 1898, 264; Millais; Pycraft, *Guide to British Vertebrates;* Trouessart.

1896. MICROTUS AGRESTIS NEGLECTUS; G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 602 (part); Trouessart (part)

1912. MICROTUS AGRESTIS HIRTUS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 673.

1913. MICROTUS HIRTUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 834.

Le Campagnol of the French; *Die Erdmaus* of the Germans.

The **synonymy** is that of the British form of *M. hirtus.* The older names, having been applied before segregation had taken place, include more than one form. The use of the specific name *arvalis* is due to confusion with the common continental species of that name, and *britannicus* arose from the same error, de Sélys-Longchamps having believed his *britannicus* to be the British representative of *arvalis*, with which alone he compared it. There can be no doubt about the application of the word *hirtus*, once the south British Grass Mouse is accepted as a distinct form.

Terminology:—Grass Mice are known under the following names in works on British mammals:—"Short-tailed Field Mouse" (Pennant, *Brit. Zool.*, ed. 2, 104, 1768; Berkenhout, 1769; Bingley, 1809, alternative to "Meadow Mouse"; Bell 1837, alternative to "Meadow Mouse" and second to "Field Vole"). "Meadow Rat" (Pennant, *Quad.*, 33, *n.* 322). "Meadow Mouse" (Pennant, *Quad.*, ii., 205; Kerr, *Animal Kingdom*, 1792, 238; Turton, 1807; Bingley, 1809, alternative to "Short-tailed Field Mouse"; Bell, 1837, alternative to "Short-tailed Field Mouse" and second to "Field Vole"). "Brown Short-tailed Field Rat" (Donovan, 1819). "Field Vole" (Fleming, 1828; Bell, 1837; Aflalo, 1898). "Field Campagnol" (Jenyns, 1835), from the French. "Brown" or "Field Vole" (MacGillivray, 1838). "Common Field Vole" or "Field Vole" (Bell, 1874; Lydekker, 1895; Millais, 1905). "Short-tailed Field Vole" (Johnston, 1905). "Common Meadow Mouse" (English).

It appears that the oldest name used by British naturalists for this animal was some form of "Short-tailed Field Mouse" or "Short-tailed Field Rat," alternating, however, freely with "Meadow Mouse," a name which is established in North America. The word "vole" = a "field," a mutilated form of "vole-mouse," appears to have been borrowed to form an English generic name by Fleming (1828) from Barry (1805), who reported it as in use in the Orkneys (see also below, p. 457). Apparently the need of some such name was felt at that period, for in 1833 Jenyns took the term "Field Campagnol," from the French. This is mentioned by MacGillivray, who declared his preference for "vole." The adoption of the latter term by Bell and MacGillivray led to its appearance in one form or another in almost every subsequent work, and it has now found what seems to be a permanent place in the technical zoological literature of the English-speaking peoples of both hemispheres. But it is quite unknown to the public and may be conveniently discarded as a specific name. The name "Grass Mouse" is very extensively used locally, and as stated above on p. 398, it is here proposed to restrict the word "vole" to the group *Microti*. The subject is discussed also by Elliot (*Proc. Berwickshire Nat. Club*, viii., 1876-1878, published 1879, 447-468); by Harting (*Zoologist*, 1893, 145); Skeat and Maxwell (*Notes and Queries*, 16th September and 21st October 1899); and by English; other references are given in dictionaries, but I have been unable to find them.

Local names (non-Celtic):—Usually *grass* or *meadow mouse*, but occasionally *harvest mouse*, as in Shropshire (Forrest); *bob-tail* or *bull-dog mouse* of Surrey (Adams); *pig mouse* (Lydekker); *waggoner* (Cocks); *water mouse* (E. R. Alston).

Welsh:—*Llygoden gwtta'r maes* (Millais); *llygoden gynffbyr* = short-tailed mouse (Forrest); but species are not usually distinguished in Gaelic dialects, *pathew* or *bathor* being also applied to mice in Wales (Caton Haigh in Forrest).

History:—Although described by Bellamy in 1839, it cannot be pretended that the status and affinities of this mouse have been made at all clear until quite recently. All the earlier descriptions, even when technically valid, must be regarded as due to misapprehensions, the earlier writers not having been acquainted with the true relationships of *agrestis* and the continental *arvalis.*

The exact **distribution** of this Grass Mouse is imperfectly known, but it certainly ranges from Wales to Austrian Galicia, ascending to 4000 feet in Switzerland (Fatio). The common European form, which is found from the eastern shores of the English Channel and the Baltic at least to Central Germany and South-western France, is just distinguishable as a sub-species, *M. h. bailloni* (de Sélys), on account of its narrower skull. Another sub-species, *M. rozianus* (Bocage) of Portugal and North-western Spain, which differs chiefly in its small auditory bullæ, is graded as a sub-species of *agrestis* by Miller, but may prove to be more nearly related to *hirtus.*

M. hirtus is the Grass Mouse of England, Wales, and the lowlands of Scotland, where it is common all over the country, including the islands of Wight and Anglesey, except in woods and on the higher hills. In the Highlands of Scotland and probably on the hills of the south, also in the Hebrides, it is replaced by one or other of the forms of *M. agrestis*, and in the Orkneys by *M. orcadensis.* It is absent from Ireland, the Isle of Man, Bardsey Island, and, as far as is known, from all other islands except those mentioned above.

Distribution in time and **Status**:—This mouse is not known as a fossil in Britain, although remains of "voles" are numerous in late pleistocene deposits. It is therefore probably a quite recent post-pleistocene immigrant, which appears to have established itself in the more low-lying and southern parts of the country, at the expense of the older forms of the *M. agrestis* type, in a manner paralleled by that of *Lepus europæus* and *Evotomys glareolus.* It appears to have arrived in Britain before the separation of Wight and Anglesey, but after that of all the other islands.

Description:—The Common Grass Mouse is distinguishable in its genus by its comparatively small size (hind foot, 17 to 18, and condylobasal length of skull not more than 24·6 to 26 mm.), small bullæ, and comparatively reddish upper side.

The **colour** of the upper side is near "tawny russet," very indistinctly overlaid with black. The sides are paler and washed with buff; the under-side and feet are light ochraceous buff, through which colour the dusky basal portions of the hairs show here and there. The tail is bicoloured, above brown, beneath like the belly.

The brightest individuals run very near *Evotomys glareolus*, but lack the clear light belly of the latter.

The **skull** resembles that of *M. a. exsul*, but is smaller and has relatively smaller bullæ.

The **teeth** are quite like those of normal *agrestis*, m^1 being without a small fourth inner angle.

Exceptional variation:—White varieties are not common, but there are a number of records of specimens exhibiting various degrees of albinism, a few quite white with pink eyes, the rest in intermediate conditions from cream to piebald. A black variety was recorded by Southwell (*Zoologist*, 1890, 216).

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 19th May 1912, average of 5 fœtuses ready for birth	34	..	..	..	..
2. 17th July 1912, average of 4 in nest; umbilical cord still showing . .	40	12	9	4	3
3. 10th July 1912, average of 6 in nest; slight down on back; umbilical cord showing on 2	45	12	9	5	3·5
4. 15th June 1912, average of 7 in nest; furred above and very slightly below; eyes and ears closed . . .	46	12·5	10	5	3·5
5. 15th June 1912, average of 7 in nest; completely furred, ears closed, eyes opening	54	14	12	5	4·5
6. 9th July 1912, average of 4 in nest; completely furred, eyes and ears closed	56	15	13	6·5	5·5
7. Male, 11th July 1912; eyes and ears open	56	17	15	7	5·5
8. Female, 30th May 1911; juvenal pelage; vagina perforate . . .	78	24	15	11	12
9. Male, 1st June 1911; juvenal pelage .	78	28	16	11	12[1]
10. Male, 28th Sept. 1912; juvenal pelage .	81	29	16	10	16[2]
11. Female, 30th Oct. 1911; adult pelage .	82	30	16	10	15[3]
12. Male, 9th Oct. 1912; adult pelage .	83	29	16	10·5	16[4]
13. Male, 31st Oct. 1911; adult pelage .	83	34	17	10	14[5]
14. Female, 28th Sept. 1912; adult pelage .	85	28	17	10	16[6]
SEXUALLY MATURE MALES:—					
1. 26th May 1911 . . .	104	38	16·5	12	31
2. 2nd June 1911 . .	108	46	18	12	28·5
3. 2nd June 1911 . . .	100	38	16	11	24
4. 10th June 1911	96	32	16	11	23
5. 11th June 1911	101	35	17	11	31
6. 11th June 1911 . .	110	39	16	11	29
7. 17th June 1911	115	34	16·5	11	25
8. 10th July 1911 (largest ever measured by Adams)	118	40	17	11	30
9. 15th July 1911 . . .	87	32	15	11	19
10. 30th Oct. 1911 . .	101	38	18	11	24
11. 6th Nov. 1911	96	38	17	11	21
12. 14th May 1912 . .	99	32	16	12	32
13. 14th May 1912 . . .	104	38	17	12	34
14. 15th May 1912 . .	98	36	17	11	25
15. 16th May 1912 . . .	89	34	17	11	19
16. 17th May 1912 . . .	104	36	16	11	33
17. 18th May 1912 . . .	103	34	16	12	32
18. 18th May 1912 . .	101	33	17	12	34
19. 19th May 1912 .	95	35	18	11	25
20. 21st May 1912	108	31	17	12	28
Average . . .	101·5	36	16·7	11·8	27·4

[1] Testis 2 mm. in diameter.
[2] Testis 1 mm. in diameter.
[3] Imperforate.
[4] Testis 1 mm. in diameter.
[5] Testis 2 mm. in diameter.
[6] Imperforate.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY (*continued*).					
SEXUALLY MATURE FEMALES:—					
1. 14th June 1909; 3 small fœtuses	82	30	16	..	..
2. 23rd June 1909; 6 small fœtuses	98	35	16	..	..
3. 12th July 1909	85	30	16	..	..
4. 15th July 1909; 6 small fœtuses	84	25	14	..	..
5. 20th July 1909; 7 small fœtuses	96	34	16	..	..
6. 24th July 1909; 5 small fœtuses	94	33	15·5	..	..
7. 2nd Oct. 1909; 5 small fœtuses	112	41	17·5	..	..
8. 11th Oct. 1909; 4 small fœtuses	94	32	16	..	..
9. 1st June 1911; 5 small fœtuses	104	41	16·5	11·5	33
10. 3rd June 1911; 3 small fœtuses	94	36	16	10	20
11. 29th Aug. 1911; 5 small fœtuses	100	36	16	11·5	29
12. 24th Sept. 1911; 2 small fœtuses	84	53	16	12	17
13. 29th Oct. 1911	94	32	16	11	19
14. 19th May 1912; 5 large fœtuses, head and body of which averaged 34	97	38	16	11	35
15. 13th June 1912; 6 small fœtuses	97	25	16	11	22
16. 20th Sept. 1912	96	32	16	11	20
17. 28th Sept. 1912; 3 small fœtuses	88	29	17	11	23
18. 10th Oct. 1913	92	34	17	11	25
19. 18th Oct. 1913	90	34	17	10	18
20. 21st Oct. 1913	98	40	17	12	27
Average	93·5	34·5	16·3	11	24

Notes on tables of dimensions:—The young make occasional excursions from the nursery as soon as they can see, but frequently retain it as their headquarters until they attain sexual maturity, which is not usually until the head and body reaches a length of 90 to 95.

Specimens with the head and body exceeding 110 are rare, but probably represent the size regularly reached by really old animals. Occasionally, even larger specimens are captured; *e.g.*, a male with head and body 123 (Coward, Cheshire). A female nursing young, but not fully grown, sent by the late Lord Lilford from Oundle, Northamptonshire, reached 117 (for further details see my paper in *Proc. Zool. Soc.*, London, 19th May 1896, 599). The status of these "giants" requires investigation. Evidently "voles" continue to grow for a long and somewhat indefinite period (*cf.* above, under *Evotomys*, p. 411).

Skull:—Condylo-basal length, 24·4 to 26; breadth: zygomatic, 14 to 15·2; inter-orbital, 3·0 to 3·4; occipital, 11 to 12·2; depth, median occipital, 6 to 6·8; length: of nasals, 6·6 to 7·4; of diastema, 6·8 to 7·8; of mandible, 15·2 to 16·2; of maxillary tooth-row, 5·8 to 6·4; of mandibular tooth-row, 5·8 to 6·4.

Grass Mice[1] are gregarious and sociable animals, restricted under normal circumstances to a diet of green stuff, preferably

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For an excellent account of the habits of Grass Mice, see Victor Fatio's *Les Campagnoles du Leman.*

the succulent bases of grass-stalks.[1] They are, however, capable, when opportunity or necessity arises, of adopting at least partially the omnivorous propensities of the Bank Mouse, and are frequently unable to resist the temptation offered by a dead body, even of one of their own kind. For the satisfaction of their wants, therefore, many different kinds of country are suitable, the main requirement being plenty of grass, which may be of any coarse kind, for their teeth are excellent slicing organs. They may be found in pastures, especially in those damp or wet places where growth is most luxuriant; on salt marshes; amongst the marram-grass of sea-beaches;[2] on moors and mountains and, especially in winter, in open patches in woods, or on grassy hedgerows in almost every conceivable situation.

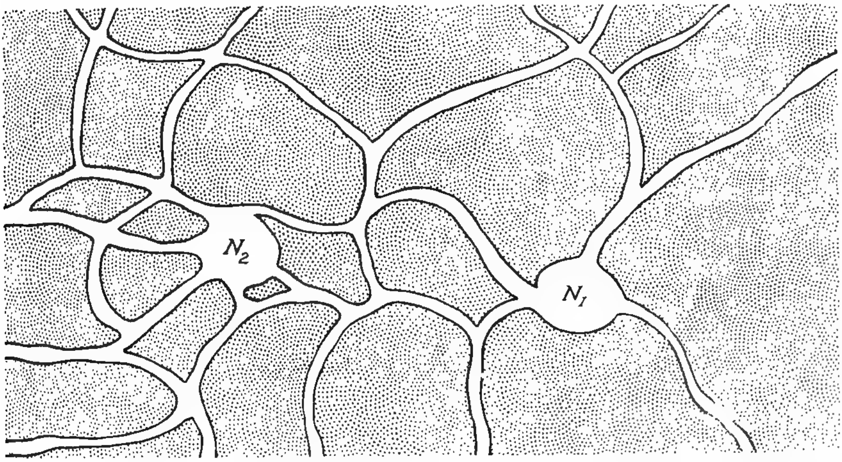

FIG. 69.—PLAN OF RUNS OF GRASS MICE UNDER A FALLEN NOTICE-BOARD, 23rd January 1910. Diagrammatic, from sketches by L. E. Adams. N_1 and N_2 nursery, with young and nest in each; scale 8 feet.

Where vegetation is thick they construct a labyrinthine network of runs, apparently the common property of the colony, lying partly above and partly below ground. They weave loose nests of grass for the reception of their young. In winter or early spring these nurseries are more frequently placed under ground or in sheltered places under logs or piles of wood; they are then sometimes lined with warmer materials such as fur and wool. In summer they are usually on the surface, invariably composed of grass, and are often very evident in hayfields by clogging the knives of the reaping machines.

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[1] Hence they can rarely be induced to enter a trap containing the usual baits, but are attracted by carrots (L. E. Adams) or bulbs of yellow crocus (W. R. Ogilvie-Grant), neglecting those of any other colour. They are easily caught in unbaited traps so placed in their runs that the animals attempt to pass through them.

[2] G. T. Rope (*Zoologist*, 1873, 3610) found them very numerous on small grassy islands; and abundant and attaining "a very large size" on a long water-bound strip of beach at Aldeburgh, Suffolk.

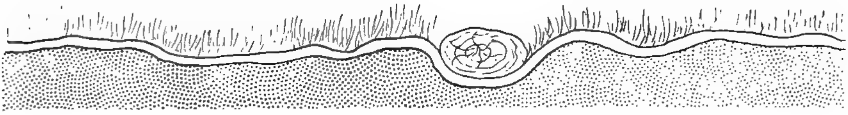

FIG. 70.—HORIZONTAL SECTION OF RUN OF GRASS MOUSE PASSING UNDER A LOG. From a sketch by L. E. Adams; scale 10 feet.

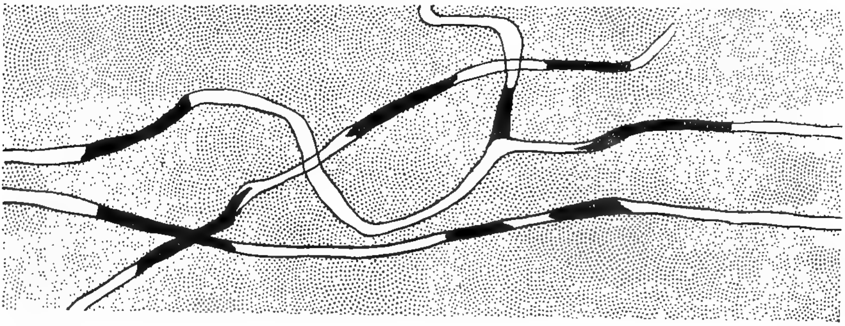

FIG. 71.—PLAN OF RUNS OF GRASS MICE IN COARSE GRASS, partially above and partially (where blackened) below ground. From a sketch by L. E. Adams; scale 12 feet.

These mice are very hardy and never hibernate, although they may be comparatively inactive in cold, damp weather. In winter they often seek more sheltered habitats than the open fields, and have been caught occasionally in cellars and outhouses; but never habitually resort to ricks and granaries. Like other small mammals, they probably suffer more from hard "black" snowless frosts and summer droughts than from snow, which makes the work of burrowing actually easier and protects both vegetation and mice from the cold.[1] In captivity the male may safely be left with his own wife and children, though he will devour strange litters, which suggests that the mice live together in pairs,[1] or at all events have some sense of property in their nests. They have also some sense of sanitation, since they deposit their ordure in little heaps at particular places, as at the mouths of their burrows. The rest of their life-history is soon told. Although not incapable of climbing, and extremely agile without being fast, they never under normal circumstances leave the ground, and may be seen running, but not bounding or jumping, to and fro in their haunts, or sitting at little bare places at the mouths of their burrows, at almost any hour of the day ; and no doubt they are equally active at night. They probably spend their time alternately in short sleeps and meals, their light slumber guarding against surprise. They are quite capable of amassing stores of food for winter use, always of such provender as will keep, but for obvious reasons this propensity is not very highly developed in the comparatively mild climate of England.

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[1] For the habits of "voles" in times of snow, see C. Hart Merriam, *Mammals of Adirondacks*, 11, 124.

They are copious drinkers and their appetite is enormous, Dr Henry Laver having ascertained[2] the weight of clover consumed by a single captive individual in one day to be six drachms (apothecary's weight = 2.3 grammes).

They are very attentive to their fur, cleaning it carefully after the manner of a cat.

At intervals, either owing to favourable weather[3]—moist summers and mild winters resulting in exceptionally nourishing vegetation—but perhaps occurring independently in a natural cycle, the numbers of Grass Mice undergo a very exceptional increase, beginning gradually and extending over several years if unchecked. More litters, and those of abnormal size, make their appearance, and presently the usual equilibrium between mice and vegetation is upset, the grass is all consumed, the mice, usually in autumn, begin to stray into woods, bark[4] trees, cut their roots, otherwise cause damage, and people become aware that it is a "vole year" or that there is a "plague" of mice. With the increased numbers there ensues a corresponding abundance of beasts and birds of prey, to which (and to dogs) the mice are extremely palatable. These participate in the exceptional fertility of their victims, and for the time being, alter the whole routine of their ordinary breeding habits. Later, disease arrives to help in the extermination of the mice, fertility drops to a minimum, the predatory creatures retire or starve, and vegetation resumes its normal aspect; the "plague" is now over. Such occurrences are now infrequent in Britain,[1] but so recently as 1891-93 the grazing lands of southern Scotland were afflicted to an extent involving an area of not less than sixty miles by twelve to twenty. Plagues on such a large scale must, however, be regarded as rare in Britain; on a small scale Service believed[1] them to be frequent, and in fact that of 1891-93 is said to have commenced in a small way in the autumn of 1887. Sometimes other species also are involved, as the Bank and Field Mice; a "run" of these two was observed by Mr A. H. Cocks[2] in 1900, and in the Forest of Dean plague of 1813-14 there was one Field Mouse to every fifty Grass Mice.[3]

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[1] Adams has taken 73 males to 24 females, a proportion of, roughly, 3 males to 1 female; but the figures, although suggestive, are too small to form the basis for a definite statement as to the relative numbers of the sexes.

[2] *Zoologist*, 1881, 461.

[3] R. Service, *Ann. Scott. Nat. Hist.*, 1892, 134.

[4] Charles Oldham (*Zoologist*, 1890, 98) once observed them engaged in barking hollies.

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[1] Plagues of mice have been known at least from the time of Aristotle (*Historia Animalium*, vi., 37) and Sennacherib, the defeat of whose army owing to the destruction by night of their quivers, arrows, and bowstrings was described by Herodotus (*Euterpe*, ii., 141). A fuller account of these and other classical references was given by J. E. Harting (*Zoologist*, 1893, 187), and see also J. G. Frazer's *Golden Bough* (*cit. supra*, p. 374). For Britain there are records of "sore plagues of strange mice," in the following years at least:—1580-81, "an extreme dripping warm year, and a mild moist winter" (Childrey), in Danesey Hundred, South Minster, Essex (Holinshed's *Chronicle*, 1315); 1648, Hundred of Rochford and Isle of Foulness, Essex (Childrey, *Britannica Baconica*, 1660, 14). An anonymous correspondent to the *Gentleman's Magazine*, 1754, 215, stated that Helgay, near Downham Market, Norfolk, had a plague every six or seven years, at which times long-eared owls arrived regularly to eat the mice, and were venerated almost like the Egyptian ibises. Prior to 1813, near Bridgwater, Somersetshire (George Montagu, *Supplement to the Ornithological Dict.*, 1813, art. "Owl"); 1812-14 (commencing in 1810 or 1811), Forest of Dean, Gloucestershire, and New Forest, Hampshire (Lord Glenbervie, *Zool. Journ.*, i., January 1825, 433-44); 1825, oak-coppices of Cameron, Dumbartonshire (Harting, *Zoologist*, 1892, 121-38); 1836, Forest of Dean, Gloucestershire (Edward Jesse, *op. cit. supra*, p. 418); 1863-64, Rannoch, Perthshire (Harting, *op. cit.*); 1864-67, woods, Drumlanrig, Dumfriesshire (Harting, *op. cit.*); 1875-(culminating in) 76 (ending in May), mainly in portions of Roxburghshire, Selkirkshire, Dumfriesshire, and Yorkshire (Sir Walter Elliot, *Proc. Berwickshire Nat. Club*, viii., 1876-78, published 1879, 447-68, a paper abstracted for the *Brit. Assoc.*, 1878), and following winters of higher than usual temperature, the frosts being slight or accompanied by snow, from February 1871 to January 1876; commencing before 1890 and ending before the summer of 1893, Dumfriesshire, Roxburgh, Selkirk, Peebles, Lanark, Kirkcudbright (*Government Report on the Plague of Field Voles in Scotland*, 1893, 174, reprinted in *Zoologist*, 1893, 121-38; see also P. Adair, *Ann. Scott. Nat. Hist.*, 1893, 193-202; Harting, *Zoologist*, 1892, 161); simultaneously in 1891-92 a plague in Thessaly (*Report cit.* and Harting, *Zoologist*, 1893, 139-45), and in 1891-93 in Norway (Collett). [Plagues are said to have occurred in Essex and Kent in the 17th century, but I have not been able to find the original references.]

The above are well summarised in the *Report cit. supra*, as also by R. Lydekker; and for mouse plagues generally, see A. Fleming, *Animal Plagues*, Philadelphia, 1871; V. Bailey, *N. Amer. Fauna*, No. 25, 116; W. H. Hudson, *Naturalist in La Plata*, ed. 2, 1892, 60-64; S. A. Poppe, *Ueber die Mäuseplage*, 1902 (including a bibliography of murine literature); S. E. Piper, *Year Book*, *U.S. Department Agriculture*, 1908, 301-8.

It is doubtful if the recurrence of mouse-years can be attributed to the destruction by game preservers and others of the natural enemies of the rodents. In a state of nature the numbers of the latter fluctuate even more markedly and probably with greater regularity than under the artificial environment imposed by civilisation, and in some cases it appears that the carnivores depend on the rodents rather than the rodents on the carnivores. The reclaiming of woods, forests, marshes, and rough pastures which protect small rodents proceeds side by side with the destruction of predaceous creatures, and it is probable that a thorough and effective system of agriculture is the best preventative of mouse plagues.

There are few detailed accounts of the breeding habits of this species. Mr J. G. Millais has seen both sexes collecting material for a nest. The average number of young is probably about five, that number having been reported by Mr Adams as the result of examining thirty-eight litters made up as follows:—

No. of Litters.	No. of Young.	No. of Litters.	No. of Young.
1	9	5	4
5	7	8	3
8	6	1	2
9	5	1	1

and these results agree fairly well with those of other observers. Grass Mice do not, therefore, produce so many young at a time as the common rats and mice; still they rear a considerable number annually in a sexual season lasting at least from April to December. In times of "plague" the number of young may run higher per litter, Service having met with ten. A pair[4] of the allied *M. arvalis* produced five young in captivity at the age of eighty-eight days on 2nd March, five more on 6th July, and again five on 30th July. The latter opened their eyes when ten days old. On the 12th day, though still very small, they began to leave their nest. On the 26th day they appeared to be nearly "grown up." In other respects the breeding habits are not known to differ from those of other mice, it being uncertain whether they are monogamous or not. Probably in this respect their customs are as loose as in other gregarious mammals.

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[1] *Ann. Scott. Nat. Hist.*, 1896, 206.

[2] See above, p. 418.

[3] Glenbervie, *op. cit.*

[4] Fernand Lataste.

The voice, often used in moments of excitement or hunger, is half a grumble, half a squeak.[1] They do not seem to chatter their teeth and stamp their feet as some exotic species do.

In captivity these mice are far more amiable than Bank Mice. Perhaps owing to poor brain power, they become tame very soon after capture, and can with difficulty be teased into biting. The young have been reared by a Field Mouse under the care of Mr F. H. Parrott[2] and by a House Mouse.[3]

They are good swimmers. Mr Rope[4] has disturbed one amongst seaweed cast up by the tide, when it made for the water and swam out boldly. Mr Bruce Campbell has observed[5] some swimming for pleasure in the sea in the Firth of Forth, at Long Green Bay, Dalmeny.

Charles Darwin comments upon the dependence upon each other of Dutch and red clovers, humble-bees, and "field mice."[6] The clovers are fertilised by the bees, and the numbers of the latter in any district depend in a great measure on the number of "field mice," which destroy their combs and nests, according to Colonel Newman, to the extent of two-thirds all over England.

Darwin believed, again, that the number of mice is regulated by the number of cats, but here the correlation is doubtful; his remarks are often read as referring to Field Mice,[7] but the facts are probably true of several species, and the Grass Mouse is the most common in situations where humble-bees nest. Grass Mice also destroy a destructive sawfly,[8] which damages larch.[9]

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[1] W. Evans. [2] Cocks. [3] Rope, *Zoologist*, 1883, 332.

[4] *Zoologist*, 1890, 330. [5] *Ann. Scott. Nat. Hist.*, 1901, 48.

[6] *The Origin of Species*, 6th ed., 37th thousand, 1883, 57.

[7] *Apodemus sylvaticus*. [8] *Nematus erichsonii* of Hartig.

[9] An exhibit to illustrate this fact was shown at the Royal Society's conversazione on 13th May 1908, by C. G. Hewitt.

GROUP ORCADENSIS.

Characters and status:—The Grass Mice of the Orkneys[1] belong to a peculiar group which appears to be an offshoot of a form not known in Britain, the continental *M. arvalis.* These are readily distinguished by their m^2, which differs from that of *M. agrestis* in lacking the small third or posterior inner angle, so that it possesses only four dentine spaces. They are all comparatively large animals with a tendency to develop exceptionally strong temporal muscles resulting in prominent modifications of the skull.

Miller regards these mice as belonging to two species, namely: *M. orcadensis*, inhabiting Pomona and the South Orkneys, and *M. sandayensis* (with two sub-species, viz., *M. s. sandayensis* from Sanday, and *M. s. westræ*, from Westray), living in the North Orkneys. Further specimens, including many old individuals, recently taken by Ogilvie-Grant on Sanday and Rousay, enabled Hinton (whose work was done since the key on pp. 377-381 was published) to show that Miller's arrangement cannot be sustained, and that all the Orkney Grass Mice must be referred to a single species—*M. orcadensis.* It appears that, as a result of long segregation in small islands, in this respect affording a complete parallel with the *agrestis* group in the Hebrides, the Orkney mice have become differentiated into at least five closely allied sub-species. With *M. orcadensis* must be associated *M. sarnius*[2] of Guernsey, Channel Islands, and the extinct late pleistocene *M. corneri*,[3] the remains of which occur at Ightham, Kent, and possibly also in France; whether any continental forms have similar affinities remains for future work to decide.

Hinton has shown that the cranial modifications of the *orcadensis* group are dependent upon the strength and size of the temporal muscles. In the young these muscles are feeble. Consequently young skulls of all members of the group are similar to each other, and have a brain-case resembling that of adults of (in this respect) less specialised Grass Mice, such as *M. hirtus;* the inter-parietal is short and broad, the coronal suture widely though deeply emarginates the parietals, and the squamosals are widely separated anteriorly in the hinder part of the inter-orbital region (Fig. 72, 1 and 1*a*). As the muscles become stronger with age, the faint ridges, which low down on each side of the skull mark the origin of the temporal fascia, become more salient and gradually ascend so that the distance between them is steadily diminished. Finally, the growth of the anterior portions of the muscles causes the ridges to meet and fuse into a sharp inter-orbital crest in adults, just as in the *agrestis* group; the anterior parts of the squamosals are stimulated to grow inwards and upwards upon the sides of the frontals until in the most advanced forms only the inter-orbital crest separates the right bone from the left; the post-orbital crests of the squamosals become more prominent, and each tends to develop an antero-external process. Under the same stimulus the parietals more extensively overlap the frontals; consequently the coronal suture and posterior processes of the frontals are reduced to a narrow notch and narrow tongues respectively (Fig. 72, 2 and 2*a*, and dimensions *a*, *b*, and 3 of table at p. 462). The growth of the posterior portions of the muscles causes the supra-tympanic parts of the squamosals to encroach upon the region occupied in the young by the lateral parts of the inter-parietal; the latter is therefore laterally reduced, and its growth becomes almost exclusively longitudinal; its greater portion is situated between the temporal ridges, and it acquires in the adults of *o. orcadensis* and *o. ronaldshaiensis* a highly characteristic pentagonal outline; the lateral processes of the supra-occipital gradually increase in saliency and the supra-tympanic fossæ, from which the hinder portions of the muscles arise,

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[1] Millais searched the Shetlands for "voles," but, although such animals seemed to be known to the inhabitants, no specimens were forthcoming.

[2] Miller, *Ann. and Mag. Nat. Hist.*, May 1909, 420.

[3] Hinton, *ibid.*, July 1910, 35.

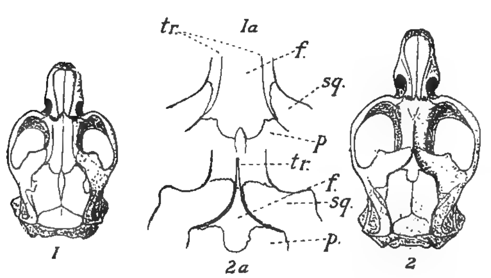


FIG. 72.—DORSAL VIEWS OF SKULLS OF *Microtus orcadensis.*

1. *M. o. orcadensis*, juv. (natural size); 1*a*, fore part of brain-case × 2. 2. *M. o. sandayensis*, adult; 2*a*, fore part of brain-case × 2; *f.* frontals; *sq.* squamosal; *p.* parietal; *tr.* temporal ridge. (Drawn by M. A. C. Hinton.)

are greatly enlarged (Fig. 72 and dimensions 8, 9, and 9-8 of table at p. 462).

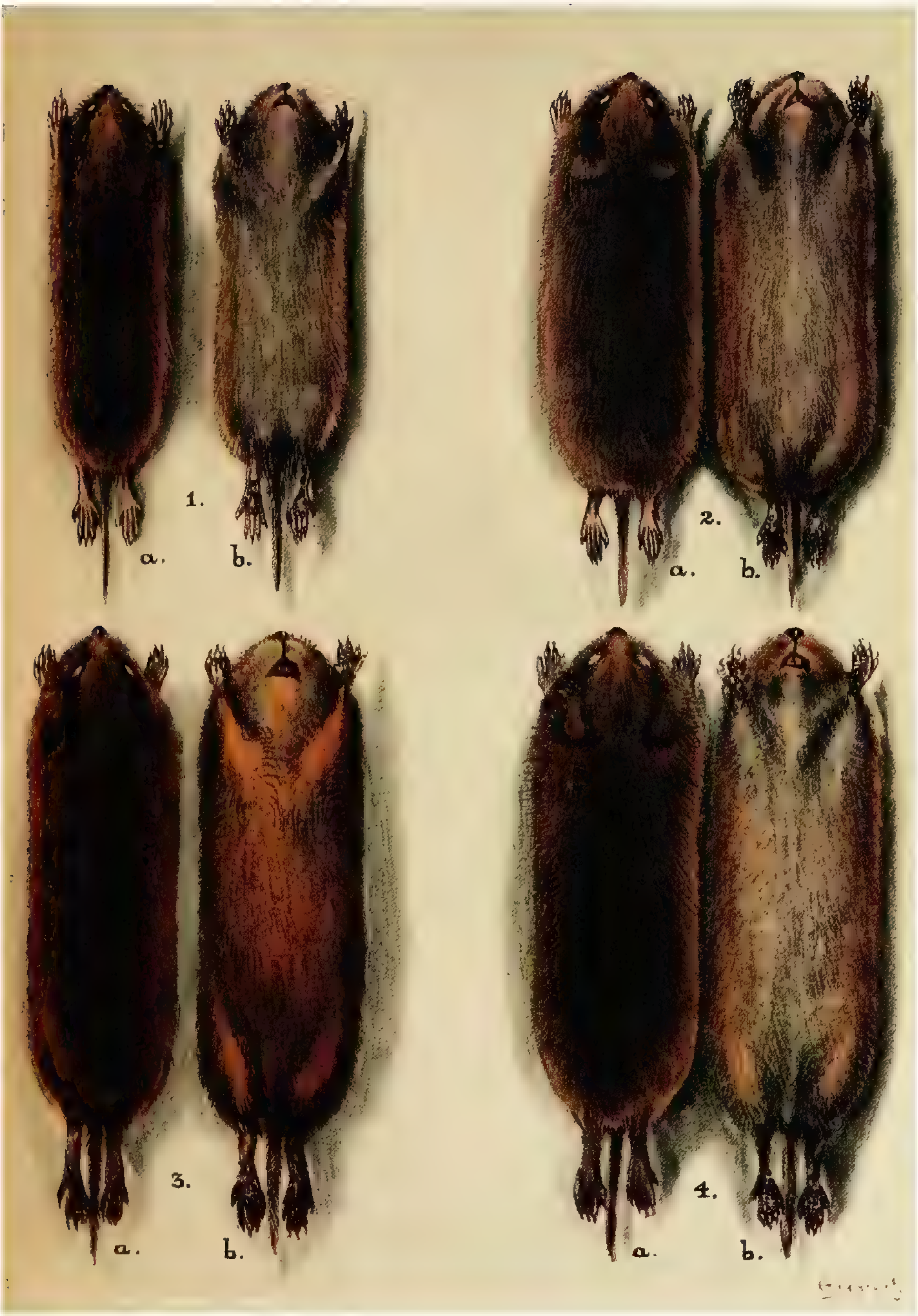
The pleistocene *M. corneri* occupies a somewhat central position between *M. sarnius* and *M. orcadensis*, but it is on the whole, as might have been expected, more primitive than either. The incisors are straightened and protruding, the cheek-teeth of normal *arvalis* pattern, but light and short; the short nasals terminate roundly behind, the diastema is long, the posterior palatal septum grooved. The zygomata are narrow, the jugals heavy with boldly convex upper borders. The brain-case is long and narrow, the occiput intermediate in depth between *o. orcadensis* and *o. sandayensis*, the temporal ridges fuse into a low but sharp inter-orbital crest, the post-orbital crest of the squamosals is weak, though long, the inter-parietal, coronal suture and posterior frontal processes are entirely unmodified in the adult, retaining to the full the form seen in young *orcadensis;* anteriorly, however, the squamosals encroach upon the frontals, the distance between the right and left bones being no greater in adults than in adult *o. orcadensis.*

The Guernsey *M. sarnius* has an external appearance which recalls *M. agrestis.* In its cranium it is more specialised than *M. corneri*, except only in one respect, the wide anterior separation of the squamosals. The rather short nasals are cleft behind; the median septum of the hinder palate has no ventral groove.

M. orcadensis stands considerably higher than either *M. corneri* or *M. sarnius.* Owing to the richness of colour and length of the fur, the external appearance of its less modified southern sub-species is not very different from that of some of the Hebridean forms of *agrestis;* in its northern races, *westræ* and *sandayensis*, the colours tend to become pallid. The temporal muscles are throughout considerably stronger than in either of its allies, and in the transition from youth to age exert a much more powerful influence upon the form of the skull. In *ronaldshaiensis* and *orcadensis* the posterior portions of the muscles appear to be more powerful than the anterior; accordingly in these forms the modification of the inter-parietal is more profound (in adults) than elsewhere. The post-orbital crests are relatively weak, the occiput deep. The upper borders of the jugals are boldly convex, and m_1 has a deep fourth outer fold. In *sandayensis* the anterior portions of the muscles are predominant, and therefore the changes in the fore part of the brain-case attain their culmination. On the other hand, the posterior portions are weaker than in *orcadensis* and the interparietal is less reduced. The occiput is depressed; the jugal convexities have disappeared so that these bones are slender; and the fourth outer fold of m_1 is obsolete. The modifications of the jugals and m_1 seen in the group are correlated by Hinton with the differential development of the two portions of the temporal muscles. The sub-species *rousaiensis* and *westræ* are intermediate between *orcadensis* and *sandayensis; rousaiensis*, on the whole, is nearer *orcadensis*, while *westræ* in some respects approaches *sandayensis*, as will be appreciated from the descriptions on pp. 458-61.

Miller points out that the distinctness of the Orkney Grass Mice amongst themselves appears to bear a direct relation to the depth of the channels between the islands, and therefore presumably to the length of time during which the colonies have been isolated. *M. o. ronaldshaiensis*, *orcadensis*, and *rousaiensis* inhabit islands separated by 6 to 8 fathoms of water, and they agree in external appearance; *westræ* and *sandayensis* with their more pallid coloration are cut off from the three southern forms by 17 to 20 fathoms, and are separated from each other by a 10 to 12 fathom strait.

Origin:—The *orcadensis* group appears to have arrived in south-eastern England in late pleistocene times, probably from France by way of the Channel Islands, which explains its absence from Skandinavia. It spread northward through Britain, becoming specialised as it dispersed, and eventually reached the Orkney district which was then part of the mainland; later, on the severance of the Orkneys from the mainland, portions, probably the northern first, became detached as separate islands. In these segregation has played its part, and differentiation of sub-species has been the result. At the time the group reached Scotland the Hebrides were apparently already separated from the mainland, for we have no evidence of the presence upon them at any time of a Grass Mouse of the present type. Hinton suggests to me that on the mainland


1.
a.
b.
2.
a.
b.
3.
a.
b.
4.
a.
b.

BRITISH *Microtinæ* (SKINS);
(1) *Microtus hirtus*; (2) *M. agrestis neglectus*; (3) *M. orcadensis*; (4) *M. agrestis exsul.*

the group became extinct through unsuccessful competition with *M. agrestis neglectus*, just as the latter succumbed in the southern and lowland districts before the advance of *M. hirtus*. The persistence of *M. sarnius* in an island far to the south shows that these mice owe their survival to freedom from competition in islands rather than to any other factor; elsewhere they have probably succumbed to such competition, helped by the attacks of carnivora, from which large palatable mice inhabiting shallow burrows can only escape in the presence of moderately deep snow.

THE ORKNEY GRASS MOUSE.

MICROTUS ORCADENSIS, Millais.

1805. MUS AGRESTIS (species), George Barry, *History of the Orkney Islands*, ed. i., 314; ed. ii., 320, 1808 (part); Low, *Fauna Orcadensis*, 1813, 25 (part); T. E. Buckley, *Trans. Nat. Hist. Soc.*, Glasgow, i., 49, 1883-86 (part).

Local names and terminology:—*Cuttick* or *puttick* (Millais); *vole-mouse* of Barry, 1805 (see under *History*), a name which seems to have been the source of the term "vole," as already discussed above on pp. 398 and 443 (see also Edmonston's *Etymological Glossary of the Shetland and Orkney Dialect*, 1866).

Distribution:—This mouse is confined to the Orkneys, where it is known from all the bigger islands except, perhaps, the rocky Hoy[1]; it is abundant in parts of South Ronaldshay, Pomona, Shapinshay, Rousay, Westray, and Sanday.

History:—This mouse was first mentioned by Barry, minister of Shapinshay, in 1805:—"The Short-tailed Field Mouse (*Mus agrestis*, Lin. Syst.), which with us has the name of the *vole mouse*, is very often found in marshy grounds that are covered with moss and short heath, in which it makes roads or tracks of about 3 inches in breadth, and sometimes miles in length, much worn by continual treading, and warped into a thousand different directions" (in ed. ii., 1808; ed. i. not seen).

Subsequently to Barry's time the mouse appears to have been known to many naturalists, none of whom examined it critically. Baikie and Heddle appear to have confounded it with the Water Rat, other writers with *M. agrestis*. In August 1886 Millais's attention was attracted by some individuals which he observed in Pomona, but he obtained no specimens until August 1887, and none were preserved until September 1898; his description of *orcadensis* did not appear until July 1904.

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[1] Note that Baikie and Heddle (*Addendum*, 97) record the capture of two specimens of *Mus amphibius* in the burn by Rackwick, in Hoy, by M. F. Heddle in September 1844.

Description:—This is a large mouse with the hind foot 17 to 20, and the condylo-basal length of the skull in adults, 27·5 to 30 mm. The southern races are dark **coloured**, the northern relatively pallid. The **cheek-teeth** are essentially as in the *arvalis* group of continental Europe; m^2 lacking the small third inner angle of the *agrestis* group; m_1, except in the most modified sub-species, having a deep fourth outer fold; and m_3 the third outer angle distinct but small. In addition to the, in some forms, strikingly narrow, subquadrate or pentagonal inter-parietal, and the other characters correlated with the exceptionally powerful temporal muscles (discussed above on p. 453), the **skull** differs from that of *M. agrestis* in its slightly greater breadth (zygomatic breadth equals 60-61 per cent. of condylo-basal length); relatively longer and anteriorly more gradually expanded nasals; slightly longer diastema; shorter and lighter cheek-teeth; and smaller, less rounded and more angular auditory bullæ. The nasals are cleft behind by a small frontal process, and the posterior palatal septum bears a well-marked ventral groove (Fig. 73, D). From that of the continental *M. arvalis*, the skull differs in its greater size and zygomatic breadth; relatively smaller bullæ; narrower palate; and lighter cheek-teeth; in addition, adults are remarkable for the far greater perfection of that cranial specialisation which results from the increased strength of the temporal muscles.

Moults take place twice a year, at the end of May and in August and September. They may be gradual, the new hairs replacing the old as they drop out; but sometimes the long black hairs and the light tips of the shorter hairs of the back are shed in a mass, leaving the animal with only the dusky bases of its fur in a condition which has been mistaken for melanism.

Further special characters are noted under the sub-species which are as follows, commencing with the most primitive and ending with the most modified:—

(1) *M. orcadensis ronaldshaiensis*, Hinton.

1913. MICROTUS ORCADENSIS RONALDSHAIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 457; described from South Ronaldshay, Orkneys; type, an adult male, No. 7.11.16.1 of British Museum collection.

Distribution:—South Ronaldshay, Orkneys.

Description:—This sub-species cannot be distinguished externally from *M. o. orcadensis*, but differs in the following cranial characters:—The brain-case is longer and narrower; the squamosals are slightly more widely separated anteriorly, their post-orbital crests less salient and without any antero-external process; the inter-parietal is slightly more reduced, the supra-tympanic fossæ being much more extensive laterally. The jugals and m_1 are as in *o. orcadensis.* For dimensions and cranial measurements, see tables at pp. 462-3.

(2) *M. orcadensis orcadensis* (Millais).

1904. MICROTUS ORCADENSIS, J. G. Millais, *Zoologist*, July, 244; described from Sandwick, Pomona, Orkneys; type, an old male, No. 4.6.21.1 of British Museum collection; also, *Mammals of Great Britain and Ireland*, 1905, ii., 278, pl. 47; Eagle Clarke and Bradley, *Ann. Scott. Nat. Hist.*, 1905, 1-8; Forsyth Major, *Ann. and Mag. Nat. Hist.*, March 1905, 323; Pycraft, British Museum *Guide to British Vertebrates;* Trouessart; Miller (*Catalogue*).

Distribution:—Pomona and possibly Shapinshay, Orkneys.

Description:—In this sub-species the **colour** of the upper side is rich, dark brown, near "clove brown," overlaid with "ochraceous buff," and passing without sensible line of demarcation into the clear, bright ochraceous buff of the under-side, the latter slightly obscured, especially on the chin and throat, by the dusky hair-bases showing through. The upper surface of the tail is blackish; the under surface, with the feet, light grey, tinged with ochraceous buff. The tail may have the tip white (Millais). The soft first coat of the **young** is duller than in adults, and at first always lacks the rufous tints on the belly; later, the belly may become rufous before the back gains the adult pelage (Kinnear).

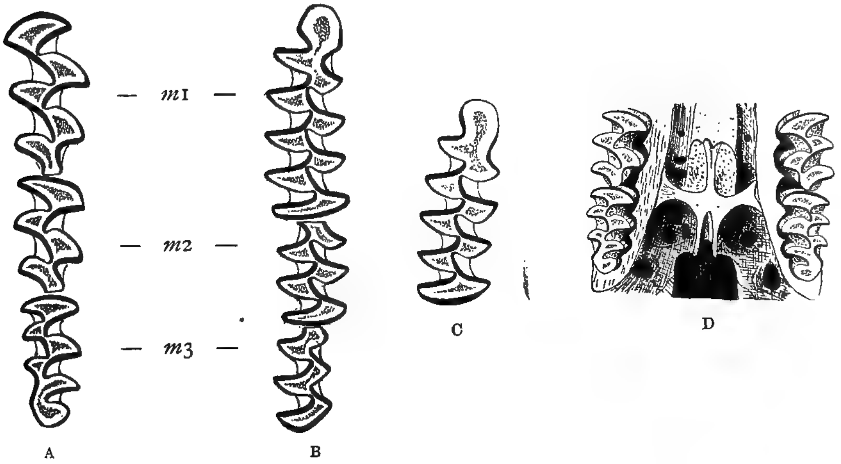

FIG. 73.—RIGHT CHEEK-TEETH OF *Microtus orcadensis orcadensis* (A, upper; B, lower); (C), RIGHT m_1 OF *M. o. sandayensis* (A, B, and C 9 times life size); (D), posterior palate of *M. o. sandayensis* (5 times life size). (Drawn by M. A. C. Hinton.)

The **skull** when adult has the brain-case short and broad; the occiput not depressed (median depth equals 55-56 per cent. of greatest width across the lateral processes of the supra-occipital); the inter-parietal pentagonal and very narrow; the inter-orbital region comparatively broad; the squamosals separated anteriorly by 1·4 mm., their post-orbital crests moderate with feeble antero-external processes; the jugals with well-marked central expansions, their upper borders boldly convex; m_1 each with a deep fourth outer infold. For external and cranial dimensions, see tables at pp. 462-3.

(3) *M. orcadensis rousaiensis*, Hinton.

1913. M. O. ROUSAIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460; described from Rousay, Orkneys; type, an adult male, No. 12.7.5.7 of British Museum collection.

Distribution:—Rousay, Orkneys.

Description:—This sub-species is externally indistinguishable from *o. orcadensis*, but has a **skull** intermediate in character between the latter and *o. sandayensis.*

The brain-case is short and broad, as in *o. orcadensis;* the occiput occasionally depressed; the inter-parietal and the supra-tympanic fossæ nearly as in *o. orcadensis;* the squamosals separated anteriorly by 1·0 mm., their post-orbital crests and processes intermediate in saliency between those of *o. sandayensis* and *o. orcadensis;* the degree of inter-orbital constriction is also intermediate; the jugals are always slender, as in *o. sandayensis;* m_1 always has a deep fourth outer infold, as in *o. orcadensis.* For external and cranial dimensions, see tables, pp. 462-4.

(4) *M. orcadensis westræ* (Miller).

1908. MICROTUS SANDAYENSIS WESTRÆ, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 199; described from Pierowall, Westray, Orkneys; type, a sub-adult male, No. 8.1.2.1 of British Museum collection; Trouessart; Miller (*Catalogue*).

1913. MICROTUS ORCADENSIS WESTRÆ, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460.

Distribution:—Westray, Orkneys.

Description:—The colour is similar to that of *o. sandayensis*, but the dark shading of the longer hairs is more noticeable, and the tips of the underfur are nearer to dull ochraceous buff. The under-side is coloured like that of *M. o. orcadensis*, but is paler, the dusky bases of the hairs taking a more prominent part in the general effect. The tail is more densely sprinkled with black hairs than in *o. sandayensis.*

The **skull** of the sub-adult type has the brain-case short and broad; the occiput is much depressed, more than in any specimen of *o. sandayensis* examined; the inter-parietal nearly as reduced as in *o. orcadensis;* the lateral processes of the supra-occipital very salient; the supra-tympanic fossæ nearly as extensive as in *o. ronaldshaiensis;* the inter-orbital region relatively broad; the squamosals not more closely approximated anteriorly than in *o. orcadensis;* the jugals slender; m_1 with the fourth outer fold sometimes as deep as in *o. orcadensis*, sometimes obsolete, as in *o. sandayensis.* For external and cranial measurements, see tables at pp. 462-4.

(5) *M. orcadensis sandayensis*, Millais.

1905. MICROTUS ORCADENSIS SANDAYENSIS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 280; described from specimens procured by George Sim, from Sanday, Orkneys; type, an immature male, No. 5.11.22.3 of British Museum collection; Hinton, *Ann. and Mag. Nat. Hist.*, November 1913, 460.

1908. MICROTUS SANDAYENSIS, G. S. Miller, *Ann. and Mag. Nat. Hist.*, February, 199; Pycraft, British Museum *Guide to British Vertebrates;* Trouessart.

1912. MICROTUS SANDAYENSIS SANDAYENSIS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 697.

Distribution:—Sanday, Orkneys.

Description:—In size this sub-species about equals *o. orcadensis*, from which it is readily distinguishable by its lighter **colour**. The upper side is nearer "hair-brown" than "mummy-brown," the tips of the underfur being between "cream-buff" and "ecru-drab." The tail is greyish white, sprinkled with blackish hairs along the median upper surface.

The **skull** differs from that of *o. orcadensis* in its more depressed brain-case (median occipital depth equals 50-52 per cent. of greatest width across lateral processes of supra-occipital); less reduced inter-parietal and smaller supra-tympanic fossæ; more constricted inter-orbital region, in which the squamosals are separated merely by the inter-orbital crest (average distance between them 0·7 mm.), their post-orbital crests salient (with well-marked antero-external processes); slender jugals; relatively slightly longer nasals and diastema; and slightly shorter cheek-teeth.

In the **teeth**, m_1 has the fourth outer fold obsolete (Fig. 73).

For external and cranial measurements, see tables at pp. 462-4.

The well-beaten runs and thoroughfares of the Orkney Grass Mouse are often conspicuous for long distances in heather or other vegetation in rough fields or hills; they are either exposed, or form tunnels where vegetation is dense. Their diameter is from 2 to 2.25 inches, or a little more than the extreme spread of the animal's whiskers,[1] and they may be found in either dry or wet ground, in the latter case sometimes tunnelling through saturated sphagnum by pools of water.

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[1] J. G. Millais, *Zoologist*, 1904, 244, and *Mammals of Great Britain and Ireland*, ii.; Robert Godfrey, *Ann. Scott. Nat. Hist.*, 1905, 195; see also N. B. Kinnear, *Journ. cit.*, 241; for other references see *Synonymy.*

CRANIAL DIMENSIONS OF *M. ORCADENSIS* AND ALLIES:—*

	Microtus orcadensis.												*M. sarnius* (type).	*M. corneri* (type).
	ronaldshaiensis.	*orcadensis.*		*rousaiensis.*				*westræ.*	*sandayensis.*					
	Adult (type).	Juv., average of 4.	Adult (type).	Sub-adult.	Adult female.	Adult male, average of 3.	Largest male (type).	Sub-adult (type).	Juv., average of 2.	Sub-adult, average of 2.	Adult, average of 12.	Largest adult (male).		
1. Condylo-basal length	29·0	24·7	28·*ca*	27·1	27·7	28·5	28·9	27·2	25·5	27·0	28·7	30·1	27·6	28·8
2. Zygomatic breadth	17·6	14·6	17·2	16·5	16·6	17·2	17·6	16·2	15·25	16·4	17·4	17·8	16·1	16·5
3. Inter-orbital breadth (least)	3·8	3·85	3·8	4·0	3·5	3·66	3·7	3·8	3·65	3·65	3·35	3·4	3·7	3·6
6. Width of brain-case between ear and zygoma	11·1	10·9	11·0	11·3	10·3	11·1	11·2	11·0	10·85	11·15	11·84	11·5	10·8	11·1
9. Occipital breadth (across lateral processes of supra-occipital)	12·9	11·27	12·3	12·5	11·9	12·53	12·7	13·0	11·3	11·9	12·6	13·2	11·7	13·0
10. Occipital depth (median)	7·2	6·2	..	6·4	6·2	6·9	7·0	6·4	6·1	6·25	6·46	6·9	6·3	7·0
15. Nasal length	9·2	7·0	8·6	8·3	8·8	8·8	8·9	7·8	7·8	8·6	9·15	9·4	7·8	7·9
17. Diastema	8·7	7·05	8·2	8·0	8·2	8·53	8·9	7·8	7·4	7·85	8·7	9·3	7·9	9·1
18. Maxillary cheek-teeth, alveolar length	6·7	6·15	6·6	6·5	6·5	6·7	6·7	6·9	6·05	6·25	6·63	6·7	6·8	6·2
Reductions : if 1. *Condylo-basal length* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2. =	60·8	59·0	61·3	61·0	59·8	60·3	60·9	59·4	59·8	60·8	60·6	59·0	58·3	57·3
6. =	38·3	44·1	39·2	41·7	37·1	39·0	38·7	40·3	42·5	41·3	39·4	38·2	39·1	38·6
15. =	31·7	28·3	30·7	30·6	31·7	30·9	30·8	28·6	30·6	31·9	31·9	31·2	28·2	27·4
17. =	30·0	28·5	29·2	29·5	29·6	30·0	30·8	28·6	29 0	29·1	30·3	30·9	28·6	31·6
18. =	23·1	24·9	23·6	24·0	23·4	23·5	23·2	25·3	23·7	23·1	23·1	22·2	24·6	21·6
Reductions : if 6. *Cranial width* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
3. =	34·2	35·2	34·6	35·4	34·0	33·0	33·1	34·6	33·7	32·7	29·5	29·5	34·3	32·4
a. Least distance between right and left squamosals in front =	18·0	31·7	12·7	21·2	8·7	9·3	7·1	13·6	18·9	19·3	6·4	5·2	29·6	14·4
b. Width of posterior process of frontals =	13·5	22·7	19·1	22·1	12·6	10·8	8·9	20·0	19·3	18·4	12·7	15·6	24·1	32·4
8. Least distance between temporal ridges in the neighbourhood of inter-parietal =	40·5	54·6	42·8	47·8	42·7	44·4	42·0	44·6	53·1	53·8	50·2	52·1	57·4	58·5
9. =	116	103·5	112	110·5	115·5	113	113·5	118	104·5	107	111	115	108·5	117
9. less 8. =	75·5	48·9	69·2	62·7	72·8	68·6	71·5	73·4	51·4	53·2	60·8	62·9	51·1	58·5
Reduction : if 9. *Occipital width* = 100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10. =	55·8	55·0	..	51·2	52·1	55·0	55·1	49·2	54·0	52·5	51·3	52·2	53·8	53·8
Length of mandible	18·6	16·4	17·5	17·4	17·8	18·56	18·8	16·9	16·1	17·2	18·2	18·5	17·6	..
Length of mandibular cheek-teeth (alveolar)	6·7	6 1	6·5	6·1	6·4	6·7	6·7	6·6	5·95	6·1	6·6	6·7	6·8	..

* These measurements (in millimetres) and calculations were made by Hinton, and have been extracted from his manuscript; the numerals or letters in the left-hand column are those by which the various positions are numbered or marked in the original tables, and they are given here to facilitate comparison in the future, when Hinton's work is published.

DIMENSIONS IN MILLIMETRES :—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
M. o. ronaldshaiensis, South Ronaldshay—					
1. Male, 23rd Oct. 1907 (type of sub-species)	126	41	19	11·5	..
2. Female, 31st Oct. 1907 (Royal Scottish Museum)	123	40	19	13	..
3. Female, 31st Oct. 1907 (Royal Scottish Museum, W. Eagle Clarke) . .	127	40	19	13	..
SPECIMENS CAUGHT AND MEASURED BY N. B. KINNEAR, AT STROMNESS, POMONA.					
MALES :—					
M. o. orcadensis—					
1. 24th May 1905	111·5	40	19	11	49·92
2. 24th ,, ...	115	39	19·5	12	46·67
3. 24th ,, ...	100	35	18	11	46 65
4. 26th ,, ...	113	39·5	19	12	62·22
5. 26th ,, ...	109	32·5	18	12	40·70
6. 26th ,, ...	109	36	18·5	11·5	38·26
7. 26th ,, ...	121	36	19·5	13·5	57·60
8. 26th ,, ...	116	38	19·5	12	49·53
9. 27th ,, ...	119	40	18·5	12	49·79
10. 27th ,, ...	122	40	19·5	12·5	55·68
11. 27th ,, ...	125	44	20	12	57 21
12. 28th ,, ...	119·5	38	18	13	56·32
13. 28th ,, ...	112	40	19	12·5	50·88
14. 28th ,, ...	120	38	17	12·5	56·38
15. 29th ,, ...	116	38·5	19	11·5	56·32
16. 29th ,, ...	121	40	19	12	58·43
17. 29th ,, ...	116	35	18	12	61·48
18. 29th ,, ...	113	36	20	11·5	46·86
19. 30th ,, ...	121	42	19	11	62·08
20. 30th ,, ...	120	38·5	18	12	46·08
21. 30th ,, ...	120	36	18·5	12·5	53·76
22. 30th ,, ...	124	40	20	11·5	57·79
Average of 22 males	116·5	38·27	18·8	11·97	57·31
FEMALES :—					
M. o. orcadensis—					
1. 24th May 1905	107	39	18	11·5	48
2. 24th ,, ...	105	38	19	11	46·08
3. 25th ,, ...	113	35	18·5	11	43·52
4. 25th ,, ...	120	35	19	11·5	46·27
5. 26th ,, ...	114	38	18·5	11·5	48·02
6. 26th ,, ...	100	32	18	12	40·06
7. 26th ,, ...	120·5	35	18	12·5	51·20
8. 26th ,, ...	125	40	19	12	59·71
9. 27th ,, ...	105	36	18·5	12	34·11
10. 27th ,, ...	102	38·5	17	11	48·06
11. 28th ,, ...	123	42	18·5	12	63·04
12. 29th ,, ...	109·5	34	18	11	42·24
13. 29th ,, ...	108	31·5	18	11·5	43·26
14. 30th ,, ...	121	41	20	13	58 50
15. 30th ,, ...	116	37	19	13	51·84
16. 30th ,, ...	114	42·5	19	12	46·08
Average of 16 females *	112·37	37·15	18·4	11·8	46·08

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* This series may be taken as consisting only of individuals born before the current season. The influence of immature specimens on the average in October, and the general subsequent increase in size (*cf.* Shrews, above, p. 92) is shown in the following table, which is also based on measurements supplied by Kinnear :—

ITEMS.	9th to 14th Oct. (12)	7th Nov. (16)	17th Nov. (8)	Dec. 1905. (9)
Maximum	105 (female)	126 (female)	126 (male)	120 (female)
Approximate average . .	93·8	102·6	106·6	109·5
Minimum	88·5 (female)	92 (female)	94 (female)	100 (female)

DIMENSIONS IN MILLIMETRES (*continued*):—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
M. o. rousaiensis—					
Four males caught and measured by W. R. Ogilvie-Grant, on Rousay, 13th and 14th June 1912.					
1. (Type)	135	36	18	12	
2.	133	41	19·5	12	
3.	127	38·5	18	13	
4.	127	40	16·5	11	.
Two caught and measured by W. Cowan, 25th August 1904.					
5. Male	126	45	20	12·5	..
6. Female	120	35	18	11	..
M. o. westræ—					
1. Male, 5th April 1906, J. Edgar, per N. B. Kinnear (type of sub-species)	108	34	18	10·5	..
2. Male, G. S. Miller	115	42	18	11	
3. Female, G. S. Miller	108	38	17	11	
MALES:—					
M. o. sandayensis—					
Two caught and measured by W. C. Wallace (per N. B. Kinnear).					
1. 3rd Jan. 1906	102	33	18	10·5	..
2. 22nd ,,	117	37·5	19	11	.
Six caught and measured by W. R. Ogilvie-Grant.					
3. 8th June 1912	119	38	17	13·5	..
4. 23rd ,,	131	42	18	13	
5. 24th ,,	125	43	18·5	11·5	
6. 27th ,,	118	39	17·5	11	
7. 27th ,,	116	38	17 5	12	.
8. 27th ,,	115	40	18	11·5	
Approximate average of 8 males	118	38·8	17·9	11·8	..
FEMALES:—					
M. o. sandayensis—					
Nine caught and measured by W. C. Wallace (per N. B. Kinnear).					
1. 3rd Jan. 1906	110	38·5	18	10·5	..
2. 3rd ,,	104	35·5	18·5	10·5	..
3. 3rd ,,	111	42	18	11·5	..
4. 3rd ,, (immature)	95	32	17	10·5	..
5. 22nd ,,	100	35	16·5	10	..
6. 22nd ,,	100	35	18	10	..
7. 22nd ,,	111	35	18 5	11	..
8. 22nd ,,	103	35	18	10	..
9. 22nd ,,	96	35	18	10	..
Four caught and measured by W. R. Ogilvie-Grant, 6 fœtuses.					
10. 9th June 1912	120	35	18	13	
11. 27th ,,	122	39	18	12·5	.
12. 28th ,,	118	34	17	12	
13. 28th ,,	98	33	17	11·5	..
Approximate average of 10 adult females, omitting (as immature) Nos. 4, 9, and 13	110	36·4	17·8	11·2	

The mice are also found on sandy ground near the sea-shore, as on Sanday. They sometimes enter cultivated fields to feed on the crops, and numbers may then be killed when the hay is cut in August.

Nests of dry grass and roots, having a greatest diameter of from 5 to 8 inches, are placed in rounded chambers in the centres of small mounds. They are never at the end of a run, but are approached by a network of paths suggestive of a mole's "fortress."

The mice may be seen in their runs all day, but that does not imply that they are not also active in the night.[1] They swim well, and Mr Millais states that if pursued they will plunge into a pool rather than go round by land; one which he released in a pond dived under the surface.

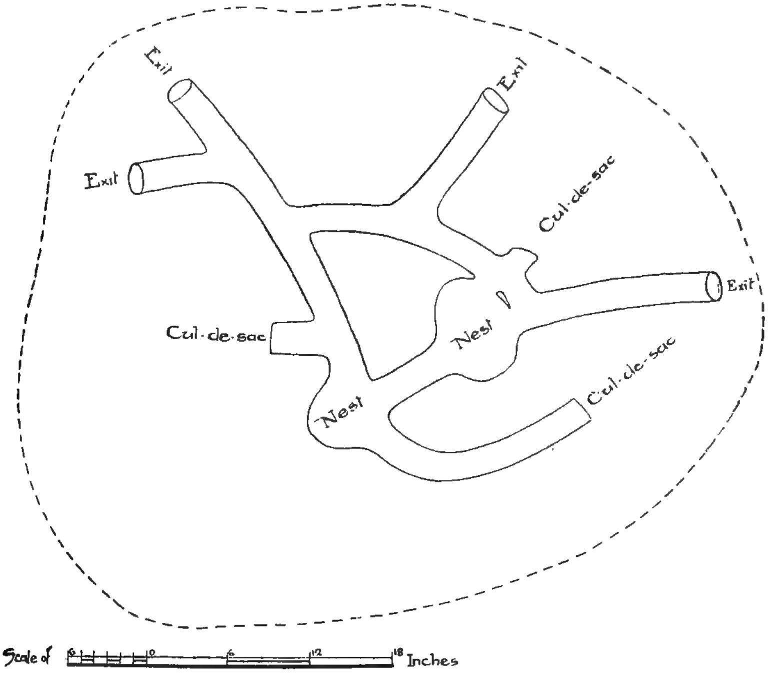

FIG. 74.—PLAN OF NESTS OF ORKNEY VOLE. (The dotted line represents the base of the mound.)

They do not seem to be very prolific nor to have a long sexual season, and for this reason, perhaps, no "plagues" are known to have occurred in the Orkneys. Mr Millais reports that the first litters appear in April, and he has seen half-grown young at the end of September. But Mr Kinnear found no young at the end of May, except one about a quarter grown.

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[1] Ogilvie-Grant caught one at 10.30 P.M.

At that time, of sixteen females trapped, several were pregnant with from two to six fœtuses.[1] Others taken by Mr Godfrey on 8th and 9th August contained fœtuses "the size of peas." Mr Robert Drane[2] has bred these mice in confinement, and states that six received in August 1904 increased to sixteen by October. There was then a cessation of reproduction until 28th February 1905, when two of the females gave birth to litters of three and four young respectively. Mr Drane definitely ascertained that the period of gestation is, as in other species, twenty-one to twenty-two days (one instance). The young of one litter opened their eyes and emerged from the nest to nibble lettuce leaves on the 12th day. At eighteen days old they were independent of their mother, who still, however, exercised parental authority and drove them home peremptorily if she considered them in danger.

Mr Kinnear found the mice fond of the roots of a common rush,[3] to obtain which they burrow under the tufts. Mr W. R. Ogilvie-Grant took the Sanday form with baits of cheese and bulbs of yellow crocus. In captivity their favourite food is grass; next, carrots. Their intelligence appears to be intermediate between that of the Bank Mouse and the Common Grass Mouse, but reports of their amiability vary, no doubt according to the manner in which they were treated. They may bite if roughly handled, will attack fresh members of their own species when first introduced to their cage, and sometimes behave with great brutality amongst themselves.[4] Females with young must be isolated to protect the litter from the attacks of strange males.

Mr Millais found that his mice became inactive during cold weather.

Like other Grass Mice, the Orkney Mouse is very palatable. Every bird and beast seems to eat it, and dogs devour it greedily.[5]

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[1] One contained two; three contained four; one contained six.

[2] *Field*, 18th March 1905, 465; also in Millais.

[3] Determined by W. Evans as *Juncus squarosa*.

[4] Drane, *op. cit.*

[5] T. E. Buckley, *op. cit. supra*, p. 49.

LOCALLY EXTINCT VOLES.

Microtus arvalis (Pallas, *Nov. Sp. Quadr. e. Glir. Ord.*, 78, 1778) differs from *M. agrestis* in its smaller size; broader, shorter, more depressed, and less angular brain-case; and in m^2 having only two instead of three salient angles on the inner side. Miller recognises four sub-species in western and central Europe, viz., *M. arvalis arvalis*, Pallas, known from Germany, Belgium, France, Switzerland, Austria-Hungary and northern Italy, characterised by its small size (hind foot, 15 to 17 mm.; condylo-basal length, 23 to 25 mm.) and normal skull; *M. a. meridianus* (Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 197) from south-western France (Pyrenees), a slightly larger, more yellowish form (hind foot, 15.8 to 16.6 mm.; condylo-basal length about 25 mm.); *M. a. duplicatus* (Rörig and Börner, *Arb. aus d. Kais. Biol. Anstalt f. Land- u. Forstwirthschaft*, v., Heft ii., 73, 1905), from the Baltic coast of north-eastern Germany, a large pallid form with robust skull and deep brain-case (hind foot, 17 to 18.6 mm.; condylo-basal length, 25 to 25.5 mm.), and *M. a. levis* (Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 197) from Rumania, southern Hungary, and north-eastern Italy, resembling *duplicatus* in its large size and pale coloration, but with the skull slender, the brain-case long, narrow, and smoothly rounded, and usually with relatively large auditory bullæ. Other nearly related forms carry the range of the species far to the east through Siberia and central Asia.

On several occasions fossils from various British deposits of late Pliocene and Pleistocene age have been determined as belonging to *M. arvalis* (*e.g.*, from fissures near Bath, Somerset, by Blackmore and Alston, *Proc. Zool. Soc.*, 1874, 468); but in most cases such records imply, because of the fragmentary nature of the material on which they are based, nothing more than the presence of a "vole" with an arvaloid, *i.e.* a normal dentition. Some rather well-preserved cranial fragments have been collected from the late Pleistocene of Ightham by Abbott, Corner, and others, and Hinton (*Proc. Geol. Assoc.*, xxi., 495) finds that these are "apparently identical" with *M. a. arvalis.*

Ightham probably marks the date of the arrival of the species in Britain, since no *arvalis*-like "vole" is represented among the many microtine fossils recovered from the Crayford brickearth, a deposit one stage older than that of Ightham.

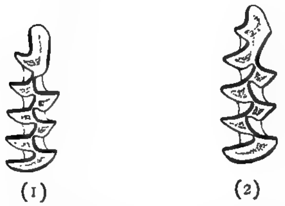

FIG. 75.—(1) FOSSIL RIGHT m_1 OF *M. anglicus* of the late Pleistocene of England; (2) of *Microtus ratticeps* (K. and B.); Pleistocene of England; 8 times life size.

Microtus anglicus (Hinton, *Ann. and Mag. Nat. Hist.*, July 1910, 36, first referred by Nehring to a little-known existing species, *M. gregalis*, Pallas) is a very remarkable species belonging to the highly specialised Asiatic group which Kastchenko calls *Stenocranius*. The skull is very long and narrow, with the long inter-orbital region greatly constricted and bearing a sharp median crest; the median septum of the hinder palate is long and thin. The upper cheek-teeth are similar to those of *M. arvalis*. m_1 (Fig. 75) is of peculiar form; it has the posterior loop and five closed triangles of normal *Microtus*, but the fourth outer angle (counting from behind) is reduced, and the fourth outer fold obsolete; the outer border of the anterior loop is long and straight, and the tooth has only three outer salient angles. m_3 has the third outer angle obsolete. The *Stenocranius* group is regarded by Hinton as an offshoot of the *arvalis* group, its cranial and dental peculiarities being apparently results of an increased development of the temporal muscles; this specialisation is similar in kind, though more intense in degree, to that described in the *orcadensis* group at p. 453. It is thus possible that instead of there being any specially close affinity between *M. anglicus* and the similarly modified forms of central Asia, the former may afford an instance of parallel evolution from a common arvaloid stock.

M. anglicus first appears in Britain in, and is perhaps the most characteristic element of, the late pleistocene fauna (Ightham), and it, or closely allied forms, had a wide range in western and central Europe. So far as is known, all such forms are now extinct in this region.

Microtus ratticeps (Keyserling and Blasius, *Mem. Acad. Imp. Sci. Nat., St Petersburg*, iv., 3, 333, 1841 (1845); described from

Wellikii-Ustjug, north central Russia) is a large, long-skulled mouse with relatively heavy teeth (condylo-basal length of skull to 30 mm., the condylo-basal length about twice the zygomatic breadth; hind foot 19 to 21); m_1 resembles that of *M. anglicus* in having only three outer salient angles, but the fourth outer angle is still more reduced and the third outer fold is shallow, so that there are only four closed triangles, the fifth opening more or less widely into the anterior loop (Fig. 75). m^3 has usually a small fourth outer angle; and m_3 has the third outer angle distinct though small.

M. ratticeps is found at the present time in northern Eurasia, from Skandinavia (in mountains and lowlands) to some point in Siberia, and south to Holland, northern Germany, and Hungary, although it has not yet been detected in Denmark (Winge, *Danmarks Pattedyr*, 78). It formerly lived in Britain, first appearing in the Clevedon Cave, Somersetshire (Middle Pleistocene), where it is accompanied only by *M. malei* and *C. nivalis*. In the "middle terrace" horizons of Crayford and Erith, and Fisherton, its remains are common and associated with those of lemmings and a pouched marmot (*Citellus*) in addition to those of *C. nivalis*. It is known also from many later pleistocene deposits, as Ightham, Forest of Dean Cave, Langwith Cave, Derbyshire, and "Dog Holes," Lancashire; in such horizons its remains are scarce and associated with those of *M. anglicus*, lemmings, *Citellus* and *Pika*, while *C. nivalis* is absent. The late pleistocene bones appear to be identical with those from individuals living in Holland and Germany. According to Hinton (*op. cit.*, 503), *M. ratticeps* reached this country with *Chionomys* from France during the later part of the "middle terrace" stage.

Microtus malei (Hinton, *Proc. Geol. Assoc.*, xx., 48, 1907, first referred to *Chionomys* and subsequently to *Microtus*, *Proc. Geol. Assoc.*, xxi., 494) is a "species with (typically) a rather generalised dental pattern such as that which probably characterised the ancestor of several species like *M. ratticeps* and *C. nivalis*," and the specimens from the Clevedon Cave upon which this species was originally based represent only its nivaloid variation. It is only known from the Middle Pleistocene of Britain, occurring in the Clevedon Cave, Somersetshire, and in the later "middle terrace" deposits of the Thames at Crayford and Erith.

Remains of several small species of *Microtus* have been found in the late pliocene Forest Bed of Norfolk. In their dental characters these recall such existing forms as *M. arvalis* and *ratticeps*, or the pleistocene *anglicus*, but they all have peculiarities which show that they belong to extinct types which probably have little real connection with those of the late pleistocene or recent faunas of western Europe (Forsyth Major, *Proc. Zool. Soc.*, 18th February 1902, 107; Hinton, *Proc. Geol. Assoc.*, xxi., 490, 1910). One of these Forest Bed forms, *M. nivaloides* (Forsyth Major, *op. cit.*, 106, Fig. 19), may possibly be a forerunner of *Chionomys.*

The sub-genus **Chionomys** was formed by Miller (*Ann. and Mag. Nat. Hist.*, January 1908, 97; based on *Arvicola nivalis* of Martins, *Revue Zoologique* (Paris), 1843, xix., 87) for the mice usually known as the "Snow Voles," and formerly referred to a single species (*nivalis*). Miller now recognises three European species; these, or their allies, are found from the Pyrenees to Asia Minor and Transcaucasia, mostly in mountains. They have rather long tails, usually of whitish colour, full soft fur, and a very characteristic slaty-grey upper side. The skull has a broad, flat, rather smooth brain-case, wide inter-orbital region, inconspicuous temporal ridges, and the hinder palate sculptured in low relief with a broad median septum. m^3 has only two folds and three salient angles on either side; in m_1 the anterior loop is small, broad, and crescentic.

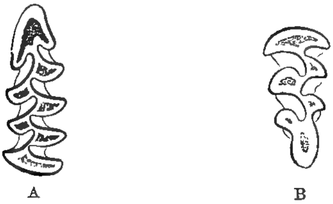

FIG. 76.—*Chionomys nivalis:* A, left m_1; B, left m^3; crown view; 7½ times life size. (Drawn by M. A. C. Hinton.)

Chionomys has been identified from numerous continental deposits of Pleistocene age, as in Lombardy, and at Parignana, near Pisa, Italy (see Forsyth Major, *Atti. Soc. Sci. Nat. Ital.*, 1872, xv., 378); in the island of Palmaria, near Spezzia; in French Switzerland; in Bohemia and Moravia (Nehring, Woldrich).

In Britain, disregarding *M. nivaloides* of the Forest Bed (which may also occur in the early middle terrace deposit at Grays Thurrock, Hinton), which cannot be referred to this sub-genus with any certainty, the later middle terrace deposits yield abundant remains of nivaloid voles. Large series of lower jaws from the Clevedon Cave, and from the brick-earth of Crayford and Erith, have been studied by Hinton (*Proc. Geol. Assoc.*, 1907, 39, and 1910, 493), who cannot separate them in the absence of skulls from those of recent members of the group.

The former wide distribution (in the lowland districts of western Europe) of this group, usually associated with high altitudes and perpetual snow, has contributed to the view that these districts were afflicted during the pleistocene period with a climate much more severe than that which they now enjoy. Hinton combats this view, pointing out that *Chionomys* is a southern group not now occurring north of the Alps and at no time known further north than Norfolk or southern Germany, and he suggests that it reached Britain from the south through France. He regards it as an ancient lowland group which has been forced to recede to mountain fastnesses before the competition of newer and stronger immigrants, and thinks that it owes its survival to the present epoch solely to the fact that it has been able to colonise the mountains, where it finds security from competitors, enemies, and frosts, beneath the Alpine snows, in accordance with the principle already advocated by Bulman (*Nat. Science*, iii., October 1893, 261-266) and by Scharff (*European Animals*, chaps. vii., viii., and ix., and pp. 54 and 56).

Hinton's argument has been very remarkably substantiated by Mottaz's rediscovery (Miller, *Ann. and Mag. Nat. Hist.*, January 1908, 97; Hinton, *Sci. Proc. R. Dublin Soc.*, N.S., xii., 264) of *M. lebrunii lebrunii* on hot plains near the French shores of the Mediterranean at Nîmes. Glacial conditions are thus shown to be anything but indispensable to the sub-genus.

The genus **Pitymys** (MacMurtie, American edition of Cuvier's *Régne Animal*, i., 134, 1831, renaming the preoccupied *Psammomys* of Le Conte, 1830, based on *Psammomys pinetorum*, Le Conte, 1828, described from Liberty County, Georgia) differs generally from *Microtus* in its greater specialisation for burrowing. The usually short fur is denser and finer, the ears and tail shorter, the eyes smaller, and there are usually only five plantar tubercles, and four mammæ confined to the inguinal region, the four pectoral mammæ of *Microtus* being absent. In the least modified species the skull differs little from that of many of the more primitive species of *Microtus;* the inter-orbital region is relatively broad, the temporal ridges little developed, the brain-case large, often depressed, and smooth. In the more specialised forms the fossorial characters of the skull (oblique truncation of occiput, straightening of the upper incisors, and the characters correlated with these two) are marked. The cheek-teeth grow persistently; m^1 and m^2 are normal, the latter sometimes with a vestigial third inner angle recalling the *agrestis* group; m^3 has three outer and three or four inner salient angles, and when most reduced its first outer triangle tends to atrophy, and is more or less confluent with the inner triangle. m_1 has three instead of five closed triangles, the pair behind the anterior loop being broadly (in European) or half (in some American species) confluent (Fig. 77); m_2 has only two closed triangles, the anterior pair being half-confluent; m_3 is normal. This description applies to all the known American and European species, but in Asia species occur which partially bridge the gap between *Pitymys* and *Microtus.* Thus Thomas has found six mammæ (including a pectoral pair) in his *P. majori* (described from Trebizond, Asia Minor, *Ann. and Mag. Nat. Hist.*, April 1906, 419), and eight (four pectoral) in his *P. carruthersi* (from the Hissar Mountains to the east of Samarkand, Turkestan (*Ann. and Mag. Nat. Hist.*, March 1909, 263); in both these forms also the tail and ears are rather long. Three species, ranged at present with *Microtus*, viz., *M. irene*, *millicens*, and *oniscus*, have been described by Thomas from eastern Asia; in these the dental characters of

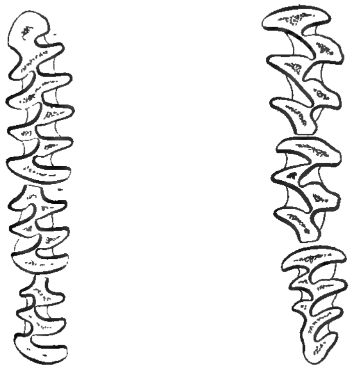

FIG. 77. — *Pitymys subterraneus.* RIGHT UPPER AND LEFT LOWER CHEEK-TEETH; crown view; 10 times life size. (Drawn by M. A. C. Hinton.)

Pitymys are combined with a peculiar skull (resembling, however, that of some species of *Microtus*, rather than any of *Pitymys*) and the essential external characters of *Microtus*.

Pitymys is of rather southern distribution, ranging in the Old World from Belgium, France, eastwards to Rumania, and south to the coast of the Mediterranean, including Greece, Sicily, and Trebizond, Asia Minor, while one species at least inhabits central Asia (Turkestan). In the New World it is found in the eastern and south-eastern United States, with Mexico.

It is numerous in species, no less than twenty-five distinct forms being recognised by Miller as European. Of these, *P. subterraneus*, De Selys, is present in Belgium and northern France, just across the English Channel. In Britain it makes its earliest known appearance, the remains of three or four species having been found in the Cromerian Upper Freshwater Bed, a late Pliocene deposit. It may then have died out, for, with the exception of a single m^2 doubtfully ascribed to it by Hinton from the early Pleistocene ("High Terrace") of the Thames Valley, no trace of the genus is known from the succeeding epochs.

Hinton regards the original home of *Pitymys* as in central or southern Asia, whence he believes that it spread westwards *via* Asia Minor to western Europe, and eastwards to North America by north-eastern Asia. The discovery of slightly more primitive species (*P. majori* and *P. carruthersi*) in Asia, and of the aberrant *M. irene* and its allies, lends support to this view.

[GENUS MIMOMYS.[1]

This genus was instituted by Forsyth Major (*Proc. Zool. Soc.*, London, 1902, i., 103-107) for his *M. pliocænicus* of the upper Pliocene of Italy, and the Norwich Crag of Britain; for his *M. newtoni* and for *Arvicola intermedius* of Newton (*Mem. Geol. Survey*, 1882, 83), both the last from the late pliocene Forest Bed of Norfolk. Both *M. pliocænicus and intermedius* have since been recorded from the Pliocene of Tegelen-sur-Meuse, Belgium (Newton, *Bull. Soc. Belge Géol., Mém. Pal.*, 21, 592-6, 1908; 24, 231, 1910), and of Gorkum, Holland (Rütten, *Diluviale Säugethiere Niederlande*, 1909-10, 88); but Hinton believes that the specimens from Tegelen referred to *M. intermedius*, really belong to *M. newtoni*, or a near ally.

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[1] Extinct. Wrongly assigned to *Phenacomys* by Nehring (*Naturw. Wochenschrift*, No. 231, 15th July 1894, 346), and subsequently included by him in his *Dolomys* (*Zool. Anzeiger*, 10th Jan. 1898, 15), from which latter it was distinguished by Forsyth Major (*supra*).

The genus is of peculiar interest, since it appears to represent the ancestral stock of modern *Arvicola*. Its members are amongst the earliest microtines found in Britain, having been detected in the late pliocene Norwich Crag.

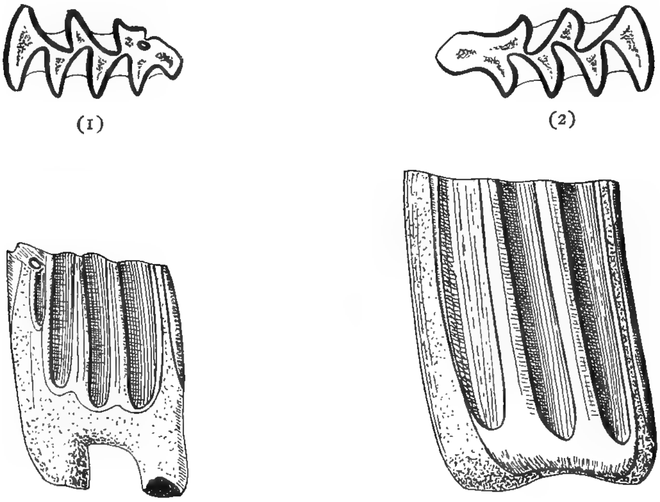

FIG. 78.—CHEEK-TEETH OF MIMOMYS: (1) left m_1 of *Mimomys pliocænicus* (crown view), from the pliocene Norwich Crag of England; (2) right m_1 of *M. intermedius* (crown view), from pliocene Upper Freshwater Bed of Cromer, Norfolk; (1*a* and 2*a*), external views of same; 2*a* is reversed to facilitate the comparison with 1*a*; 8 times life size. (Drawn by M. A. C. Hinton.)

Judging from the jaws and teeth, some species (*M. newtoni*) agreed in size with medium-sized *Microtus*, others (*M. intermedius*) with lemmings. The general pattern of the cheek-teeth resembles that of *Arvicola*, but, instead of growing persistently as in the latter, they are provided with roots when adult. In *M. pliocænicus*, m_1 has in young stages of wear a third outer infold or valley formed in the way normal in cheek-teeth of *Microtinæ;* in later stages (Fig. 78) this infold is reduced, its inner part being converted into an enamel islet which persists as a conspicuous feature of the grinding surface until a very advanced stage of wear has been reached. m^3 of this species has its second inner infold reduced by insulation of the internal part in a similar way. The roots of the cheek-teeth are developed early in the existence of the individual, and m^1 and m^2 have each three roots.

M. pliocænicus also occurs in the lower Forest Bed series at East Runton, and is there associated with more highly developed species, in which, however, the second inner infold of m^3 is not reduced. In two of these later species (*M. intermedius;* and *M. savini*, Hinton, *Proc. Geol. Assoc.*, 3rd June 1910, 491) the third outer infold of m_1 develops as in *M. pliocænicus*, but the process of reduction is accelerated; the enamel islet is found only in young stages of wear, and entirely vanishes before the roots begin to appear, which is at a later moment in the life of the individual than in *M. pliocænicus;* in addition, m^1 and m^2 have each only two roots. Hinton concludes that these later forms were not directly descended from *M. pliocænicus*, but from a similar, though slightly more primitive, animal. In the upper Freshwater part of the Forest Bed the more advanced species alone occur, *M. pliocænicus* having by that period become extinct.

Besides the above species, *M. newtoni* of the Norwich Crag and the lower part of the Forest Bed, is a small form with cheek-teeth of a less reduced type than those of *M. pliocænicus;* both in it and in *M. reidi* of Hinton, from the Weybourne Crag, the tooth-roots are formed early in life. The latter differs from *M. pliocænicus* in its small size, confluent dentinal spaces, and the much more transitory presence of the islet in m_1. In the upper Freshwater Bed of West Runton (top of the Forest Bed series), in addition to *intermedius* and *savini* noticed above, there occurs a third form, *M. majori* (Hinton, *op. cit.*); in this the third outer valley of m_1 is not reduced at all, but is normally developed. In the early pleistocene High Terrace Drift of the Thames Valley remains of another species have been detected, *M. cantianus* of Hinton (Hinton and White, *Proc. Geol. Assoc.*, June 1902, 414; Hinton, *op. cit.*, 491); the cheek-teeth of this form resemble those of *M. intermedius* in pattern, but their roots are developed only in senile stages of growth. Remains of still other species of *Mimomys* are known from the late Pliocene deposits, but these have not yet been satisfactorily defined.]

GENUS ARVICOLA.

1799. ARVICOLA, Lacépède, *Tab. des Mammifères*, 10, based on *amphibius;* Lataste, *Le Naturaliste*, October 1883, 349 (sub-genus); Miller, *N. Amer. Fauna*, No. 12, 66, 23rd July 1896 (sub-genus); Miller, *Ann. and Mag. Nat. Hist.*, February 1908, 195 (genus).

1836. HEMIOTOMYS (sub-genus), E. de Sélys-Longchamps, *Essai Monographique sur les Campagnols des environs de Liége*, 7 (part), based on *Arvicola* (=*Microtus*) *fulvus* = *M. arvalis* and *A. terrestris* = *amphibius.*

1857. PALUDICOLA (sub-genus), J. H. Blasius, *Säugethiere Deutschlands*, i., 333 (part); based on *amphibius* = *scherman*, *nivalis*, and *ratticeps;* preoccupied by *Paludicola* of Wagler, 1830, a genus of amphibians.

1867. OCHETOMYS, L. J. Fitzinger, *Sitzungsb. k. Akad. Wiss.* (Wien), lvi., June, 103; based on the Water Rats of Europe.

1867. PRATICOLA, Victor Fatio, *Les Campagnols du Bassin du Leman*, 36 (part); based on *amphibius* = *scherman*, *nivalis*, *arvalis*, *ratticeps*, and *campestris* (=*arvalis*); preoccupied by *Praticola* of Swainsson, 1837, a genus of birds.

Synonymy:—The full synonymy is given in Miller's *Catalogue.* The name *Arvicola* was for a time used to designate a large genus, including the bulk of the *Microti.* It is antedated in that sense by *Microtus*, but proves to be available for the Water Rats.

Although it is convenient to treat the Water Rats as a genus, they are not very sharply differentiated from the Grass Mice (*Microtus*), from which they differ mainly in their larger size; relatively longer tails; in possessing lateral musk-glands; normally five, instead of six, plantar pads; and m^3 with 3 + 3 salient angles and 2 + 2 infolds, as in *Chionomys.* Many of the species are aquatic; but others are more or less subterranean. The **fur** is long and suitable for commercial purposes, but, doubtless owing to the small size of the animals, is not widely used.

Distribution:—The Water Rats have a wide range in the Palæarctic Region, north of the Himalayas, from Norway (to the outermost Skerries) and Wales, at least to the river Amoor (Schrenck), and from the Norwegian shores of the Arctic Ocean with corresponding zones in Siberia to the Mediterranean coasts of Spain and France, Central Italy, Bosnia, Rumania,

WATER RATS

Asia Minor to Northern Palestine (Tristram), west and north Persia, and the Altais. They ascend to about 4500 feet in the Alps and Jura (Fatio). The relationships of east Asiatic forms have not yet been worked out, and it is not known if they really belong to the genus *Arvicola*. *Microtus calamorum* of Thomas, described from reed-beds at Nanking, seems to be allied to the North American sub-genus *Aulacomys*, which in external form represents *Arvicola*, but has the enamel-pattern of *Microtus;* the single species inhabits boreal zones in mountains from Alberta south to Oregon.

Distribution in time:—Hinton finds small unidentified species of *Arvicola* in the middle Pleistocene of Grays Thurrock and Ilford, in which they appear to have represented *Mimomys* of previous horizons. The genus is not again encountered until the Ightham horizon, in which *A. abbotti* (Hinton, *Ann. and Mag. Nat. Hist.*, July 1910, 34) is numerous. This is undoubtedly a member of the *scherman* group, differing from existing species in its larger size and more extreme fossorial specialisation, as shown especially in the straightened incisors, sloping occiput, and greatly reduced inter-parietal. The genus may have owed its survival to the fact that, after the disappearance of *Mimomys*, it had no competitors, and had nothing to fear from subsequent immigrations, which seem to have caused the extermination of the older forms of *Evotomys* and of *Chionomys*.

Geographical variation:—Miller recognises seven European species, of which *A. amphibius*, the British Water Rat, is described below. *A. sapidus* of Miller, of the entire Iberian Peninsula and north through the Pyrenees at least to Garonne, France, is an aquatic form, most nearly allied to and resembling *A. amphibius*, but with broad nasals. *A. terrestris* (Linnæus) of Skandinavia, and eastwards at least into Russia, the Caucasus and Elburz Mountains, is smaller than *A. amphibius*, with yellower cheeks and skull slightly but evidently modified for a fossorial existence; the rostrum and occiput tend to be obliquely truncate, and the inter-parietal subquadrate in outline; the teeth are rather heavy, the upper incisors projecting, the roots of m_1 and m_2 not forming protuberances as in *A. amphibius*. *A. italicus* (Savi) of Italian Switzerland and Italy, at least to

Pisa, resembles *A. terrestris*, but has less heavy teeth, lighter colour, and cheeks not in contrast with the surrounding parts. *A. illyricus* (Barrett-Hamilton) of Bosnia differs from the last in having whitish under parts. *A. musignani* of de Sélys, at present known only from the west coast of central Italy (Rome), is a pallid edition of *italicus*. *A. scherman* (Shaw) is a fossorial and partially terrestrial form with three sub-species, inhabiting continental Europe from Belgium and the Baltic to the Pyrenees, Alps, and Tirol; it has both palmar and plantar pads reduced in size, the skull distinctly fossorial, the inter-parietal bone being narrow and ligulate, and the incisors projecting; one of its sub-species, *A. s. monticola* (de Sélys), of the Pyrenees is strictly terrestrial and mole-like, and is of special interest because of its relationship to *A. abbotti* of the late Pleistocene of Britain (see under *Distribution in time* on last page).

The **habits** resemble those of *Microtus*, except as modified by a special tendency to either an aquatic or a fossorial existence.

Origin:—*Arvicola* is evidently of Asiatic origin. The distribution of the North American *Aulacomys* suggests a real relationship, but the time has not yet come for a final decision.

THE BRITISH WATER RAT.

ARVICOLA AMPHIBIUS (Linnæus).

The British Water Rat occurs as two sub-specific forms described below. It is found all over England, Wales, and the mainland of Scotland, but is absent from Ireland and probably all other islands except Anglesey and Wight.

Terminology:—It is the "Water Vole" of text-books, a name which originated, as in the case of other British species, with Fleming. All previous authors wrote of the "Water Rat," apparently translating the "Rat d'eau" of French naturalists (*e.g.*, Buffon, *Hist. Nat.*, vii., 368, t., xliii.). Jenyns's "Water Campagnol" seems never to have become popular. The word "craber" from the French crabier, an abbreviation from *raton crabier* (*cf.* Walton, *Complete Angler*, ed. 2, 73, 1655, "the craber which some call the water-rat"), seems to have fallen into disuse.

Local names (non-Celtic):—*black*, or *water dog*, Aberdeenshire (Macgillivray); *earth-hound* (*cf.* Norwegian *Jordrotte* = "earth rat") heard once by Sim; *water mole* of Cambridge (Jenyns); *water ratten* of upper Nidderdale; *water rat*—universally.

(Celtic):—Scottish Gaelic—*radan-uisge* = "water rat" (C. H. Alston); *lamhalan*, perhaps from *famh-alan* = "water mole." Welsh—*llygoden y dwfr* = "water rat" (Forrest).

In general appearance and **characters** the British Water Rat is typical of the genus *Arvicola;* in size it is larger than other European species, excepting *A. sapidus.* The tail is somewhat more than half as long as the head and body. As compared with *Epimys norvegicus* it has the body heavier and more robust, the tail relatively shorter, and the head distinctly more rounded. Although the ears (Pl. XXVI., Fig. 1) are well developed, they are inconspicuous, barely show above the fur, and when laid forward hardly reach half-way to the eyes. They are on both surfaces thinly clothed with rather long hairs, subcircular in outline, and with well-developed, bluntly triangular, naked meatal valves. The small eyes lie about half-way between the ears and the muzzle. The nostril-pad is small and naked, its lower border continuous with the naked median groove of the upper lip. The upper incisors project slightly when the mouth is closed.

The **hands** are broad and robust, but not specialised in any particular direction; the rudimentary thumbs are smaller than the smallest palmar pads, but carry distinct nails covering their dorsal surfaces; digit three is longest, slightly exceeding four, as four does two, five reaching about to the base of four; all the digits are scaled on their under surfaces, and carry slender slightly curved claws, equal in length to about one-quarter of their digit.

The **feet** are large and slightly fringed, apparently for swimming; of the digits the first is smallest, reaching about half-way to the base of the second; the second, third, fourth, and fifth are much as in the hand, as are the scales and claws, the latter, however, stronger than in the hand; except for a slight sprinkling of hairs on the posterior third, the soles are naked. The pads are variable both in size, and, sometimes, in number, being evidently in course of reduction. As a rule they are comparatively small, and the small internal proximal one appears only as a smooth spot, so that the total is normally five, but occasionally six are present. In one specimen the feet showed a confused mass of tumid flesh without true differentiation into pads.

The **tail** tapers noticeably from a thick base; when laid forward it reaches about to the shoulders or slightly beyond; the annulations are irregular, but clearly visible and not concealed by the hairs—about 15 to the centimetre at the middle of the tail. The numerous hairs are 4 to 5 mm. long and form a slight terminal tuft.

The **mammæ** are as in *Microtus.*

There are on the flanks, about half-way between the root of the tail and the scapulæ, paired **vascular glands**, oval in structure (17 × 12 mm.

in size), and each with its long axis parallel to that of the body.[1] Their slightly raised surfaces are closely and irregularly wrinkled so as to present a honeycombed appearance, caused by a series of pits, from the cavities of which arise hairs resembling those of the ordinary pelage; these hairs become scarcer towards the centre of the glands, so that they may sometimes appear to be naked; in dried skins their positions are indicated by the grease-soaked fur. These glands recall those of the shrews.

The **fur** is close, dense, and long; the underfur thick and woolly.

The **colour** (when not melanic) is normally dark brown, varying from "broccoli-brown" to "mars-brown" or darker, deeper along the back, lighter but not decidedly yellowish on the face and sides; the cheeks not in contrast with the surrounding parts. The sides are usually somewhat "lined" with black. The chest and belly vary between ochraceous-buff and slate-grey, the latter derived from the basal portions of the hairs. The feet are some shade between "hair brown" and "ecru drab," sometimes blackish; the tail is blackish, the underside sprinkled with greyish hairs.

There are two irregular **moults**, the summer coat being shorter and often redder, owing to the absence of the long hairs with dark tips. The post-juvenal coat of the young resembles that of the adult in summer.

The **skull** is large, with prominent ridges when old, and, as compared with that of *Microtus*, the occiput and rostrum tend to be obliquely truncate instead of nearly vertical; the nasals at their widest region (in front) are conspicuously narrower than the rostrum; the incisive foramina are much shorter and narrower; the auditory bullæ are relatively small; and the basi-occipital wide.

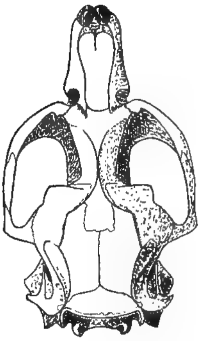

FIG. 79.—DORSAL VIEW OF ADULT SKULL OF *Arvicola amphibius*; natural size. (Drawn by M. A. C. Hinton.)

In the **teeth** the upper incisors, which are anteriorly deep yellow, are not conspicuously projecting; compared with those of *Microtus* they are somewhat straightened and protruding, but to a much less extent than in the *scherman* group. The cheek-teeth (Pl. XXVIII.) are large and heavily built, the enamel-pattern well defined and distinct, with sharp and definite angles; the base of m_1 forms evident protuberances on the lower surface of the mandible in old individuals. m^3 is simpler than in *Microtus*; the anterior loop is followed by a small outer and a larger inner closed triangle; the terminal loop is simple; a third closed external triangle is sometimes isolated; this tooth has on each side normally three salient angles and two infolds, the posterior angles being sometimes poorly developed.

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[1] Adams kindly examined a number of individuals for these glands; he finds that they occur in both sexes.

m_1 has the posterior loop preceded by three alternating closed triangles, two of which are internal; in front of these are an outer and an inner triangle, more or less confluent with each other, and opening into the short rounded anterior loop; the fourth (second outer) triangle is sometimes closed, and then the tooth has an appearance recalling m_1 of *M. ratticeps;* there are three outer and four inner infolds, and the same number of salient angles, with, in addition, a more or less prominent vestige of a fourth outer and a fifth inner angle anteriorly; the latter are clearly defined in very young teeth, but disappear rapidly with wear.

The remaining cheek-teeth are essentially as in normal *Microtus;* m^2 has three outer and two inner salient angles; in m_2 the anterior triangles are not completely cut off from each other by the antero-external fold; in m_3 the outer triangles are well developed, and the postero-external fold is usually deep enough to isolate the first outer from the first inner triangle.

Status, origin, and distribution in time:—*A. amphibius* is most nearly allied to *A. sapidus* of southern France and the Iberian Peninsula, and not to the Skandinavian *terrestris.* It probably owes its distinction from *sapidus* to isolation. It is not known as a fossil, the representative of the genus at Ightham being *A. abbotti*, a member of the older *scherman* group. It is evidently a recent member of the British Fauna, not old enough to have reached any of the islands except Anglesey and Wight.

The sub-species are as follows:—

THE SOUTH BRITISH WATER RAT.

ARVICOLA AMPHIBIUS AMPHIBIUS (Linnæus).

1758. MUS AMPHIBIUS (species), Carolus Linnæus, *Systema Naturæ*, x., 61, xii., 62, 1766; described from England and based on the *Mus major aquaticus* of Ray; Berkenhout; Turton; Walker; Bingley; Donovan.

1828. ARVICOLA AQUATICA, John Fleming, *History of British Animals*, 23; the specific name from Leach, *Syst. Catal. Spec. Indig. Mamm. and Birds, British Museum*, 1816, 7 (a *nomen nudum*); Gesner (1551); Merrett (1666); Charleton (1668); Sibbald (1684); and Ray (1693).

1835. ARVICOLA AMPHIBIA, Leonard Jenyns, *Manual of British Vertebrate Animals*, 33 (part); Bell, ed. 1 and 2; MacGillivray; Owen (part?).

1842. ARVICOLA AMERICANA, J. E. Gray, *Ann. and Mag. Nat. Hist.*, 226; described from half-grown specimens supposed to have been taken in South America, and of which co-types are in the British Museum.

1845. ARVICOLA AMPHIBIUS, sub-var. NIGRICANS, E. de Sélys-Longchamps, *Atti della Sesta Riunione degli Scienziati Italiani* (Milan), 1844, 322; without description, hence a *nomen nudum.*

1857. ARVICOLA AMPHIBIUS (a.) J. H. Blasius, *Säugethiere Deutschlands*, 344 (part).

1895. MICROTUS AMPHIBIUS, Richard Lydekker, *Hand-book to the British Mammalia*, 216; Aflalo; Johnston.

1905. ARVICOLA AMPHIBIUS, J. G. Millais, *Mammals of Great Britain and Ireland*, ii., 287; Pycraft, British Museum *Guide to the British Vertebrates*, 1910, 8 and 81.

1910. ARVICOLA AMPHIBIUS AMPHIBIUS, G. S. Miller, junr., *Proc. Biol. Soc. Wash.*, xxiii., 19, 23rd March, and *Cat. Mamm. Western Europe*, 1912, 730.

1910. ARVICOLA TERRESTRIS AMPHIBIUS (part), E. L. Trouessart, *Conspectus Mammalium Europæ*, 194.

The **synonymy** is that of the species and typical sub-species *amphibius*; that of the black sub-species *reta* is given in the article on that animal. The British Water Rat is undoubtedly the *Mus amphibius* of Linnæus, who adopted it from Ray's *Mus major aquaticus* of England. He states that it is a species not closely examined by himself, and perhaps not really distinct from his *Mus terrestris*, under which name he had just previously lumped all the other European water rats. Misled by Ray he described it as *plantis palmatis*, i.e., with the hind feet webbed, which led Gilbert White (letter x. to Pennant, 4th August 1767) to comment on the description, which he found, but for the webbed feet, applied exactly to a rat which he had himself discovered on the banks of "our little stream."

Distribution:—This is the Common Water Rat of England and southern Scotland, where it is numerous in suitable localities throughout the mainland, and occurs in the Isle of Wight and Anglesey. It ascends to 800 or 1000 feet in Wales (Forrest); and in Dumfriesshire, in May 1887, W. Evans saw a buzzard catch one on the hills above Loch Skene, at an elevation of about 2000 feet. Somewhere north of the watersheds of the Clyde and Tay (H. A. Macpherson and Aplin, *Zoologist*, 1892, 281-293), it gives way to the northern sub-species *reta*, but no exact details are available. There are black colonies in Norfolk and Cambridgeshire, the status of which is not known.

Description:—This is a large Water Rat, with hind foot reaching 32-35 mm., and condylo-basal length of skull 42 mm. or more in adults. The colour is moderately dark, black rarely replacing brown on the upper surface, and melanistic specimens are comparatively rare.

Exceptional variations are comparatively frequent, and there are a good many records of partial or complete albinos, as well as of pied (see Service, *Ann. Scott. Nat. Hist.*, 1896, 206), grey, and reddish sandy individuals. As is usual in such cases, the tendency to variation in a particular direction seems to be inherited, and more than one white or whitish individual may be observed in the same locality at or about the same time.

Melanism (considered apart from the regular sub-species, *A. a. reta*) is rather frequent, but local, being considered rare in the south of England and Wales. Millais gives a list of counties in which it has been observed, and remarks that the southern melanistic specimens are darker in summer than in winter, and are never so black as those from the north of Scotland, *i.e.*, as *M. a. reta.* White spots on breast, forehead, or tip of tail are frequent (see Service, *Ann. Scott. Nat. Hist.*, 1904, 66-67).

Skull (adults):—Condylo-basal length, 40 to 44·6; breadth: at zygomata, 23·6 to 26; at inter-orbital constriction, 4·2 to 5·4; at occiput, 17·8 to 20·6; median occipital depth, 10·4 to 11·6; length: of nasals, 10·2 to 12·2; of diastema, 13 to 15·6; of mandible, 24·8 to 29·8; of maxillary tooth-row, 9 to 11·4; of mandibular tooth-row, 9·4 to 11·4.

THE BLACK WATER RAT.

ARVICOLA AMPHIBIUS RETA, Miller.

1832. ARVICOLA ATER, William MacGillivray, *Mem. Wernerian Nat. Hist. Soc.*, vi., 429 (published January); described from Aberdeen, Scotland; preoccupied by *Hypudæus terrestris*, *β. ater* of Billberg, 1827=*Arvicola terrestris.*

1835. ARVICOLA AMPHIBIA, var. *β*. A. ATER, Leonard Jenyns, *Manual of British Vertebrate Animals*, 33.

1910. ARVICOLA AMPHIBIUS RETA, G. S. Miller, junr., *Proc. Biol. Soc. Wash.*, xxiii., 19, 23rd March; a new name for the preoccupied *Arvicola ater* of MacGillivray; Trouessart; Miller (*Catalogue*).

History:—The Black Water Rat was described by MacGillivray in 1830, as distinct from "the brown kind," and confined to Scotland. He compared it only with brown individuals existing with it, with the result that he was unable to find satisfactory differences other than of size and colour, and consequently relinquished his species. In 1835 and 1841, Jenyns (*Ann. and Mag Nat. Hist.*, June 1841, 268-9), and 1846 (*Observations in Natural History*, 76), confirmed the differences in size, but noted a few exceptions, the largest he had ever examined having been black. He reported the occurrence of Black Water Rats sometimes known as "Water Moles," in the fens of Cambridgeshire. In Norfolk, Lubbock also noticed them, and drew attention to the "considerably" larger size of the brown forms, their different habits and custom of never mating with the black, thus suggesting their distinctness. In 1892, H. A. Macpherson and Aplin (*Zoologist*, 281-293), tracing the distribution of melanism in Water Rats, found that, although occurring sporadically in many widely separated districts of England, it is well established only in the fen country of Cambridgeshire and Norfolk. In Scotland it is very local south of the Trossachs in the west and the watershed of the Tay on the east coast; north of these districts black individuals occur almost as generally as the brown. Macpherson and Aplin regarded these black animals as merely varieties. In 1910 Miller (*op. cit.*) confirmed MacGillivray's original opinion, but on different grounds. He showed that the black colour of Scottish individuals, being a geographically limited character accompanied by smaller size, is of sub-specific value. The sub-species undoubtedly needs further investigation, especially in regard to the black colony inhabiting the fen country, which may be composed only of melanistic examples of true *amphibius*.

Distribution:—North of the watersheds of the Clyde and Tay, the Black Water Rat is generally present and abounds in suitable streams and lochs, apparently to the exclusion of *A. a. amphibius*. There are no records as to how far it goes up the hills. Some writers (*e.g.* Lydekker) report it as absent from Argyll, but this is not the case. In the Forth district a colony has been known to exist near Colinsburgh, Fife, for many years (W. Evans). On the other hand, records of it from the Orkneys (Baikie and Heddle, *addendum*) are probably based on confusion with *Microtus orcadensis;* those from Islay, Mull (E. A. Alston), and Skye (Macpherson and Aplin, *op. cit.*), on *M. agrestis*. This sub-species must not be confounded with sporadic instances of melanism occurring in England. In Cambridgeshire and Norfolk, however, black individuals predominate so as almost to suggest that they represent an isolated colony of *M. a. reta*.

Description:—This Water Rat is on the average smaller than the typical sub-species. The hind foot usually reaches a length of not more than 30-32, and the condylo-basal length of the skull usually less than 42 mm. The colour is normally darker, and black often replaces brown on the upper surface; melanistic specimens are frequent.

Black and brown individuals may occur in the same litter (W. Evans, *Ann. Scott. Nat. Hist.*, 1910, 53).

Skull (Adult Male, British Museum, 5.5.12.1): — Condylo-basal length, 41·9; breadth: at zygomata, 24; at inter-orbital constriction, 4·2; at occiput, 18·5; median occipital depth, 11·3; length: of nasals, 12·2; of diastema, 13·5; of mandible, 27·9; maxillary tooth-row, 10·4; of mandibular tooth-row, 10·3.

Status:—Judging by its distribution and analogy with other mammals, the Black is an older form than the Common Water Rat, by which it has been driven out from the lower parts of the country, except perhaps Cambridge and Norfolk. But it cannot be a very old member of our fauna, since it is absent from all the Scottish islands. A statement of Boyd Watt—that the black form was first recognised in the Clyde area in August 1842 at Ballantrae, Ayrshire (whence John Thompson Sinclaire sent it to Thompson, see *Nat. Hist., Ireland*, iv., 1856, 13), but by John Colquhoun's time it had become extinct, although previously common in the river Stinchar—at first sight supports the above supposition. Thompson, however, states that Sinclaire found "the ordinary animal much more common," so that we may be here only dealing with melanistic specimens of *A. amphibius* proper.

DIMENSIONS IN MILLIMETRES AND WEIGHT IN GRAMMES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SEXUALLY IMMATURE MALES:—					
Arvicola amphibius amphibius—					
1. West Runton, Norfolk (A. Ruddle), 19th Sept. 1912	130	77	32	13	..
2. Six, Reigate, Surrey (L. E. Adams), Sept. and Oct. 1913 . . .	133	94	22	15	93
	165	111	33	14	165[1]
	172	117	34	16	170[2]
	175	105	35	15	170[3]
	175	112	35	18	180[4]
	185	115	35	17	218[5]
SEXUALLY IMMATURE FEMALES:—					
Arvicola amphibius amphibius—					
1. Three, West Runton, Norfolk (A. Ruddle), Sept. 1912 . . .	118	68	29	11	..
	129	83	32	14	..
	135	79	32	15	..
2. Seven, Reigate, Surrey (L. E. Adams)	155	115	33	15	164
	160	107	32	14	156
	165	103	32	15	163
	170	108	30	15	170[6]
	183	103	31	15	195
	185	112	30	15	175[6]
	185	125	35	15	185
SEXUALLY MATURE MALES:—					
Arvicola amphibius amphibius—					
1. Four, Reigate, Surrey (L. E. Adams), 1918	185	125	33	..	270
	190	110	34	..	241
	190	124	34	17	255
	195	140	35	18	284
2. Two, Earlsfield, Surrey (C. H. B. Grant), April 1899	185	110	31	17	..
	193	128	35	16	..
3. Thursley, Surrey (G. Dalgleish, *Zoologist*, 1908, p. 194)	192	129	36	17	..
4. Five, New Forest, Hants (G. S. Miller), 3rd July 1899 . .	214	111	34	18	..
Do. do. 1st July 1899 . .	214	127	38	16	..
Do. do. 5th July 1894 . .	219	111	36	17·4	
Do. do. 9th July 1894 . .	219	132	36	17	..
Do. do. 1st Sept. 1894 . .	219	136	39	18	..
5. Exeter, Devon (E. Hollis)	197	121	33	16	..
6. Two, Graftonbury, Hereford (De Winton), 22nd May 1894	205	130	31	..	..
Do. do. 21st June 1894 . .	208	106	32	..	..
7. Diss, Norfolk	206	139	35	..	..
8. Two, Oundle, Northamptonshire (Cox), 12th June 1904	204	114	32	20	..
	208	125	29	18	..
9. Four, Read's Island, River Humber (Capt. D. E. Hume), 28th Feb. 1896	185	127	33	15	..
	190	123	32	14	..
	194	127	32	12	..
Do. do. 28th March 1896 .	207	140	37	15	..
10. Waith Beck (G. H. Caton Haigh), 18th May 1895	210	118	36	..	..
Averages . . .	201·3	124	34	15·8	..

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[1] Testis 4 mm. in diameter. [2] Testis 4 mm. in diameter. [3] Testis 5 mm. in diameter.
[4] Testis 9 mm. in diameter. [5] Testis 5 mm. in diameter.
All these specimens were born in the year of capture. (Adams.)

[6] With the exception of these two specimens all were imperforate; all were born in the year of capture; and none (including the perforate specimens) would breed before the following spring. (Adams.)

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SEXUALLY MATURE FEMALES:—					
Arvicola amphibius amphibius—					
1. Five, Reigate, Surrey (L. E. Adams), 1913	175	120	34	16	213
	175	120	34	16	225[1]
	181	120	33	17	226
	185	125	33·5	..	..
	205	144	35	16	255
2 Three, Shalford, Surrey (W. R. Ogilvie-Grant), Sept. 1906 . . .	183	112	31	17	..
	186	108	31	17	
	201	117	33	17	..
3. Two, New Forest, Hants (G. S. Miller), 2nd July 1893 . .	195	105	37	16	.
Do. do. 1st July 1894 . .	204	125	36·4	16	
4. Two, Exeter, Devon (E. Hollis) .	178	110	32	16	
	182	108	33	15	
5. Cheadle, Staffordshire	185	118	33	..	
6. Great Kimble, Bucks (E. Hollis) . .	185	119	33	18	..
7. Wendon Lofts, Essex (A. Wright), 13th Dec. 1894	170	92	30		..
8. Cambridge (Tom Orpen), 26th May 1894	189	118	30	..	241
9. Two, West Runton, Norfolk (A. Ruddle), Sept. 1912	174	104	34	18	..
	186	122	35	16	..
10. Two, Great Grimsby, Lincs (G. H. Caton Haigh), 15th Nov. 1895 . .	174	114	28	.	..
Do. do. 24th July 1895 . .	220	113	30	.	..
11. Two, Read's Island, River Humber (Captain Hume), 28th March 1896 .	190	123	32	14	..
Do. do. 29th March 1896 .	194	127	32	12	..
Average . . .	187·1	116·5	32·7	16	..
MALES:—					
Arvicola amphibius reta—					
1. Glenfesshie Forest, Inverness-shire (G. A. Cooper), 29th April 1905	190	125	32	16	..[2]
2. Lanbryde, Morayshire (W. Taylor), 30th Jan. 1911	163	102	32	16	..
3. Collieston, Ellon, Aberdeenshire (Hon. J. E. Edwardes), 28th Aug. 1912 . .	172	88	33	15	..
4. Cortachy, Forfarshire (E. A. Wilson), 27th July 1908	163	96	32	17	..
5. Two, Windygates, Fife (N. B. Kinnear), 2nd July 1905	174	113	31	15	..[3]
	160	108	32	15·5	200[3]
6. Two, Blackwood, Kirkmuirhill, Lanarkshire (N. B. Kinnear), 25th March 1904	169	100·5	31	..	..[3]
Do. do. 22nd April 1904 .	183	107	31	..	..[3]
FEMALES:—					
Arvicola amphibius reta—					
1. Cortachy, Forfarshire (E. A. Wilson), 27th July 1908	162	97	32	17	..
2. Windygates, Fife (N. B. Kinnear), 2nd July 1905 . .	194·5	109	30·5	14·5	148
Do. do. 8th August 1904 .	182	114	31	18	..[3]
Do. do. 26th Oct. 1906 . .	160	102	30	14	..[3]
Do. do. 26th Oct. 1906 . .	157	95	29	14	..[3]
Do. do. 24th Oct. 1906 . .	155	95	28	15	..[3]
3. Kirkmuirhill, Lanarkshire (N. B. Kinnear), 5th Oct. 1904 . .	163	..	33	14	156[3]
Do. do. 9th Oct. 1904 . .	152	96	31	13	142[3]
Do. do. 9th Oct. 1904 . .	142	92	32	13	128[3]
Do. do. 10th Oct. 1904 . .	154	91	31	14	142[3]

[1] With 5 large embryos.

[2] The skull shows that this specimen is an aged individual; the condylo-basal length is 41·9 mm., the ridges are strongly developed and fused in the inter-orbital region.

[3] All these specimens are probably immature, and some of them are brown in colour.

Water Rats may be regarded as large Grass Mice which have adapted themselves to a predominantly aquatic life, but without specialising so far as to lose the power of resuming a terrestrial existence. Their love of water is shown in their comparatively long tail, used no doubt for steering purposes; thicker, more beaver-like coat; well developed aural valves; reduction in size and number of foot-pads; and slightly fringed feet. In other respects they have not been specially modified in any really important detail for amphibian existence; but their life by ponds and watercourses has led them to construct a somewhat peculiar type of burrow, and they show a preference for certain water-loving herbs, which are not usually in the path of the ordinary Grass Mice.

Our own Water Rat, although a comparatively large animal and hunted by many predatory creatures, to which it is extremely palatable, manages to exist in numbers in a region wherein all other members of its sub-family, except the smallest, have been exterminated. Several large voles allied to or identical with the Skomer Bank Mouse, the Northern and Orkney Grass Mice and the Snow Mice,[1] flourished in south Britain in the late Pleistocene period, but now exist only in the sanctuaries afforded by islands or mountainous regions. The Water Rat alone remains, partly no doubt because it has no direct competitors amongst the members of its own sub-family and partly because it has adopted the happy expedient of relying on water for a retreat from its enemies. By doing so it incurs the risk of being snapped up by herons,[2] pikes, large eels,[3] and trout, and it is a staple food of owls, stoats, polecats and, perhaps, foxes; but it avoids many of the other enemies of its tribe. Like all water dwellers in cold or temperate countries it suffers from inundations which drive it from its burrows; from frost, a combination of these two being most inconvenient; or droughts; but on such occasions it is always at least as much at home on dry land as would be a Grass Mouse of similar size, and, not being by any means lacking in climbing powers, it regularly takes refuge in the stumps of old willow trees.[1] During protracted floods large numbers are sometimes destroyed, but the altered conditions seem never to last long enough to effect the animal's extinction, and its numbers recover in the security of the ponds and ditches and sluggish rivers, which, rather than swift, gravelly streams, are its favourite summer haunts. But it is not tied to these, and when abundant may be found almost anywhere within a reasonable distance of water—in gardens, corn-fields, coastal marshes, hill-streams, or even sand-hills by the sea-shore.[2] In the north-western Highlands it frequents the limestone burns, where it takes shelter in holes in the limestone.[3]

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[1] *Chionomys*, see p. 470.

[2] J. G. Millais has seen a heron kill a small one, and T. A. Coward and Charles Oldham find the pellets thrown up by herons (*Cheshire*, 55) consisting almost entirely of the fur of Water Rats.

[3] *Nat. Hist. Trans. Northumberland and Durham*, v., 1877, 341; for an eel seizing a Water Rat's tail, see J. D. Patchett, *Field*, 12th September 1891, 431.

It is at all times an expert swimmer and diver, vastly more so, as Mr A. H. Cocks has observed, than the scarcely less aquatic Brown Rat,[4] but, although it progresses rapidly under the surface, its methods are those of ordinary terrestrial mammals, since it uses all four limbs for purposes of propulsion, and on the surface swims with its head and upper part of its back above the surface. Mr Aubyn Trevor-Battye[5] has, however, observed that, when it is not in a hurry, its fore legs may rest at its sides, the hind legs doing all the work.[6] There is no evidence to show how long it is capable of remaining below the surface. If frightened, it usually contrives to emerge under some cover.[7]

Although the young are for some time comparatively helpless, they can swim at an early date, even before their eyes open.[8] Monsieur Fernand Lataste has described the first attempts in this direction of a young male of the allied continental Water Rat.[9] This was taken from its nest before its

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[1] E. Hollis (*MS.*) took one from a hole in an oak, 12 feet above the ground. The tree not being hollow, the rat must have climbed up by the outside.

[2] H. A. Macpherson ; W. Evans.

[3] J. A. Harvie-Brown and Macpherson, *North-west Highlands*, 1904, 42.

[4] Millais (ii., 292) strangely puts the facts in exactly the opposite way.

[5] *Pictures in Prose*, 1894, 215.

[6] Beavers swim with the fore paws motionless under the chin (L. E. Adams).

[7] According to Mr Douglas English, *Some Smaller British Mammals* (undated), if cover is absent, it will bring up a leaf or other material in its mouth from the bottom.

[8] H. G. M. Williams, *Zoologist*, 1857, 5788.

[9] *A. sapidus.*

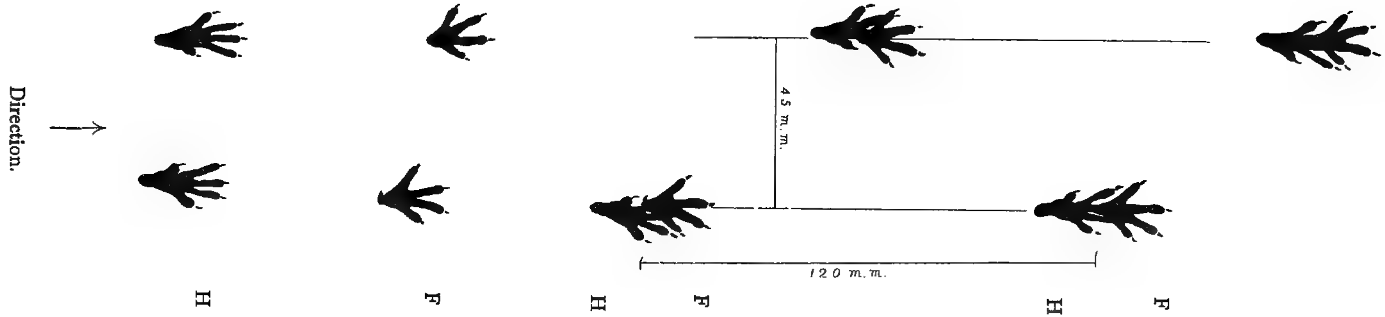

FIG. 80.—SPOOR OF WATER RAT IN SNOW.

(From a Sketch by L. E. Adams.)

H = Marks of hind feet ; F = Marks of the fore feet.

Each hind foot strikes the ground a little behind the point vacated by the corresponding fore foot ; in this track the left imprints are well in advance of the right ones.

[*To face p.* 488.

eyes had opened and soon began to show discontentment by its cries and restlessness. The moment it was given access to water it became happy, but on the first day restricted its natatory excursions to traversing the vessel in a straight line, keeping its head always dry. The next day it crossed, still in a straight line, but below the surface. The third day it dived again, circling many times before emerging, and from that time it continued to perfect its aquatic education.

The Water Rat has a second quite distinct tendency not usually recognised by those who regard it as an almost entirely aquatic animal, namely, a mole-like power of digging. It may thus be caught in regular mole-runs,[1] or may even excavate its own tunnels, throwing up "hills" at intervals in their construction. This is a procedure which it sometimes adopts when raiding gardens or grass-plots,[2] to reach which it sometimes travels long distances from water, one having been taken, for instance, in the stables of Hopton Rectory, at a distance of about a mile from the Little Ouse,[3] and another in a kitchen garden in a small town.[4] One identified by J. H. Gurney[5] was killed on the lighthouse-cliffs of dry sand at Cromer, Norfolk, some miles from any running stream.

Like the Water Shrew amongst British insectivores, the picturesque surroundings of its most favoured haunts, its diurnal habits and non-sensitiveness to observation, perhaps owing to its poor sight, have combined to render it an attractive animal to lovers of nature; its size renders it easy to observe, so that its method of eating, swimming, and transportation of its young have often been described[6]; all are, however, quite normal, except that, perhaps owing to danger from floods, it may carry its young about more than other animals, having been frequently noticed to transport the whole of its family in turn. The parent dives or swims with a young one in its mouth, holding it, according to Mr C. E. Pain,[1] who saw the removal of five half-grown youngsters, under the throat near the fore legs. The leaf of a water-lily often forms a temporary receptacle.

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[1] William Thompson, E. W. H. Blagg, *Zoologist*, 1894, 223; *Field*, 27th February 1909, 377; H. Laver, *Journ. cit.*, 6th March 1909, 419. This propensity appears at its height in the continental *A. scherman*, some races of which are entirely terrestrial and mole-like in their habits (D. Pierrat, *Feuille des Jeunes Nat.*, 1st March 1882, 62).

[2] J. Duns, *Proc. R. Phys. Soc.* (Edinburgh), session cix., 1879-80, 352-55, 1880; and session 1886-87, 325, 1887; Fleming (clover). H. Daniells, *Zoologist*, 1847, 1768 (grass); S. Gurney, *Journ. cit.*, 1851, 3265; Adams, *MS.*; Charles Stewart, *Hist. Berwick Nat. Club.*, xiv., 171; Millais.

[3] J. G. Tuck, *Zoologist*, 1898, 122. [4] E. B. Durham, *Field*, 27th June 1891, 980.

[5] *Field*, 21st April 1894, 550.

[6] One can "enjoy his society with greater intimacy than any other British mammal"—Millais, ii., 291; note also Calverley's poem on *The Water Rat*. It is often true that small mammals are more easily observed than large ones. W. P.

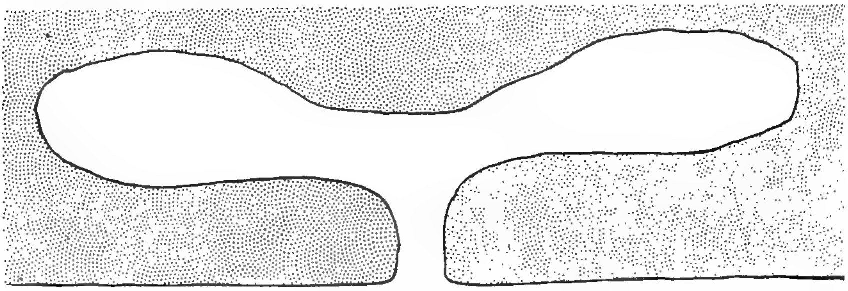

FIG. 81.—HORIZONTAL SECTION OF REFUGE OF WATER RAT, with two chambers, each large enough to hold one individual. (Diagrammatic, from a sketch by L. E. Adams.)

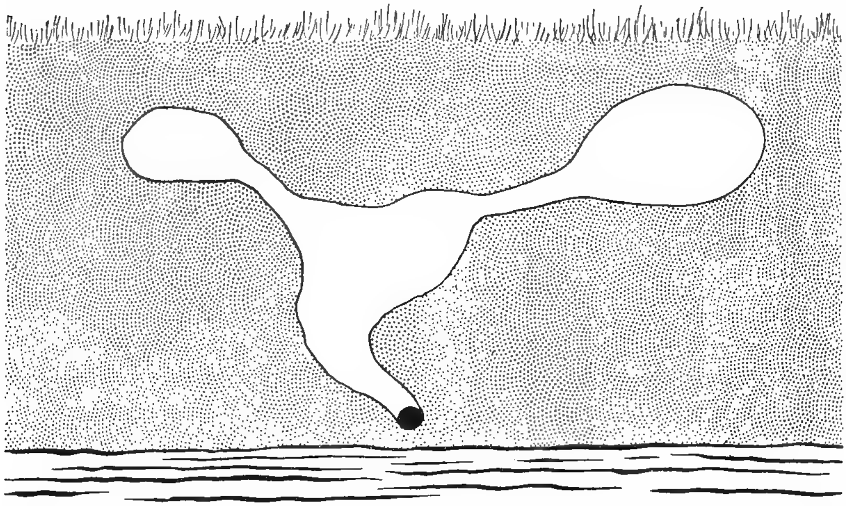

FIG. 82.—REFUGE OF WATER RAT IN A STEEP BANK (width of refuge, 7 feet), the entrance just above normal water-level; more complicated than in Fig. 81. (Diagrammatic, from a sketch by L. E. Adams.)

Taylor (*Mammals of the* 1909 *Nevada Expedition, Univ. California Pub. in Zool.*, 24th June 1911, 221) finds difficulty of approach bearing a direct ratio to the size of the species to be observed, and Elliott Coues had already come to the same conclusion (*Key to N. Amer. Birds*, ed. v., 15, 1903).

[1] *Field*, 6th June 1903, 950.

The burrows of the Water Rat have been specially studied by Mr L. E. Adams.[1] They are sometimes so numerous as to cause serious damage to embankments or masonry.[2] Although the entrances are frequently under water, that position is probably accidental, it being difficult to construct one below waterline. The funnels usually run straight for a distance of about a foot, after which they turn abruptly to right or left and end in an enlarged chamber. They are in such cases mere refuges into which the rats may retire for a short time when frightened. Sometimes they are Y-shaped with two terminal chambers,

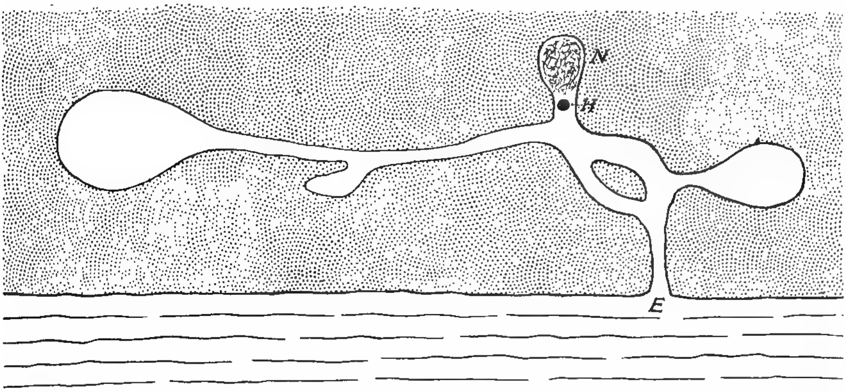

FIG. 83.—COMPLICATED BURROW OF WATER RAT (length, 6 feet), with Nursery (N), and Ventilation Hole (H), viewed from above. (Diagrammatic, from a sketch by L. E. Adams.)

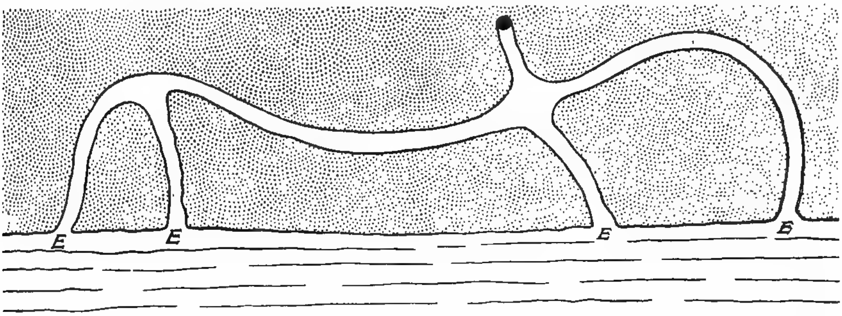

FIG. 84.—COMPLICATED BURROW OF WATER RAT (length, 10 feet); E, E, E, E, entrances at water front; entrance on land side blackened. (Diagrammatic, from a sketch by L. E. Adams.)

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[1] They were also described, although not altogether accurately, by P. H. Emerson, (*Norfolk*, 332).

[2] See, for instance, *Zoologist*, 1845, 858 (Anon.); S. Gurney, junr., *Journ. cit.*, 1851, 3265.

which may be at varying distances from the entrance, and at no time do the passages lead much below the surface of the ground, the type of excavation thus somewhat resembling that of Bank Mice.

The burrows rarely show any traces of occupation such as food, droppings (which are usually deposited by the water), nests, or nurseries. When the latter are present a ventilation hole may be provided, but where there are reed-beds or other herbage, they are quite frequently placed on the ground exactly like those of Grass Mice, and occasionally in hollow willow trees. In size and composition they resemble those of waterhens, the material used—reeds and grass—not being invariably shredded,[1] as is always the case with Grass Mice.

For breeding purposes the Water Rat prefers tributary streams and backwaters to main rivers. To these it retires in pairs early in spring, and the young, which sometimes number as many as eight,[2] may be seen on the banks throughout the summer, occasionally in April,[3] but more usually from May until autumn, so that several litters are probably reared by each couple. The male probably remains with his mate throughout the sexual season and does not harm his young; they probably grow at about the same rate as Grass Mice.[4]

The Water Rat, although without doubt predominantly a vegetable feeder, has, like others of its family, no objection to an omnivorous diet. The extent to which such wider tastes are indulged is, as in other similar cases,[5] very variable, depending probably on a number of predisposing factors. In eating, it usually sits up like a squirrel, holding the food in its hands, and where the favoured diet consists of roots or stalks they are often severed beneath the surface, brought up or allowed to float, and then recovered. Water Rats have been observed to eat, amongst other things, grass, clover, portions of sword-flags, purple loosestrife, winter cress, creeping ranunculus, marsh marigold, pondweed, leaves of duckweed, stems of the white water-lily, horse-tails, fallen leaves of willow, ivy and black poplar, acorns, and more rarely beet, mangels, swedes, and potatoes.[1] In winter it may attack the roots and bark of young trees and shrubs in orchards[2] or plantations,[3] and has long been known to be occasionally destructive to osiers and bullrushes. Messrs H. J. Charbonnier and C. Lloyd Morgan accuse it of climbing nut-bushes to carry off the nuts, and Mr C. E. Wright has seen one sitting on a bird's nest eating haws like a Bank Mouse. It has been convicted of devouring small fish, earthworms,[4] insects,[5] and even young ducks. The latter must be regarded as quite exceptional provender,[6] unless already dead,[7] the fish quite occasional, but the invertebrates more frequent. Mr F. J. Aflalo has seen it fishing up larvæ from the bed of the Hampshire Stour, Mr Gordon Dalgliesh[8] has taken it in traps baited with meat, Mr Forrest gives an instance of its eating a dead trout lying on the bank of a stream, and Mr A. Patterson[9] does not scruple to call it an omnivorous consumer of frogs, toads, crayfish, dead fish, and swan mussels.

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[1] Adams, *MS.*; for a figure of a surface nest see M. S. H. Smith, *Naturalist*, 1912, 7; the surface nests were also described by Oldham, *Naturalist*, 1892, 4. Collett writes that the nests of the Norwegian *A. terrestris* have two entrances.

[2] Number of young:—Adams has found five (6th May), five, three, and two; Pennant, six fœtuses; Aflalo, seven; W. Evans (*MS.*), seven, still blind, in nest, 14th May 1898; Jenyns, eight fœtuses in a black female, 15th June 1830 (*Observations in Nat. Hist.*, 1846, 76); Collett reports ten in an *A. terrestris* in a special "vole" year.

[3] E. R. Alston.

[4] One still blind but able to swim, taken 16th June, opened its eyes on 23rd June—H. G. M. Williams, *op. cit.*

[5] Compare the Hedgehog, a primarily insectivorous, but frequently carnivorous mammal.

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[1] Five black Water Rats were found in a potato pit at Airds, Newabbey; R. Service, *Ann. Scott. Nat. Hist.*, 1904, 67.

[2] Duns, *op. cit.*; T. B., *Field*, 412 (piece of barked apple tree sent to editor).

[3] J. Hardy, on the authority of correspondents, stated (*Proc. Berw. Nat. Club*, viii., 189, 1877) that the roots of young sycamores, willows, and oaks planted near water frequented by Water Rats had been gnawed across, and the Water Rats were thought to have done the damage; but it does not appear that specimens were actually caught in the act. At Cocks's former home at Great Marlow, two or three magnolias of fairly large growth were killed at different times, by the bark being gnawed away just above the ground by Water Rats.

[4] It is sometimes recorded to have been taken with fishing flies, perhaps by an accidentally wide cast.

[5] E. R. Alston (in Bell); C. M. Butlin, *Field*, 15th October 1910, 758.

[6] Collett gives an instance of a Norwegian Water Rat emptying the nest of a wheatear.

[7] W. Evans saw a half-eaten young redshank lying at the entrance of a burrow; probably the bird was not killed by the Water Rats.

[8] *Zoologist*, 1902, 66; for a similar instance in the case of a roach, see P. M. Watkins, *Field*, 8th December 1907, 1024.

[9] *Trans. Norf. and Norw. Nat. Soc.*, vi., 293, 6th April 1897, 1899; *Zoologist*, 1898, 306 ("Mammalia of Great Yarmouth"); *Journ. cit.*, 1902, 111; *Eastern Norfolk*, 1905, 317; *Norfolk Estuary*, 1907, 335.

The dead fish question he proved by observation and by pegging down a roach with the special object of catching the criminal. As to the deliberate catching of live fish, the Rev. F. R. Jourdain[1] has seen one eat a small trout, Mr W. P. Birch[2] reports an instance of a live minnow being taken when used as bait, and Mr H. H. Gray[3] believes that trout are taken up to 10 inches in length. Altogether there can be no doubt that the Water Rat will eat dead fish, but the evidence for its active piscivorous propensities in other directions, although supported by Charles St John, is meagre, and it certainly has not the Otter's ability to capture fish in fair pursuit.

The fact that Water Rats may eat fresh-water mussels was long ago suspected by J. H. Gurney,[4] R. F. Tomes,[5] and Sir Edward Newton, the latter of whom made the suggestion to Mr A. Patterson.[6] All three found very suspicious heaps of dead shells always perforated either nearly opposite, or else at the hinge. Mr Patterson has since seen one carrying a mussel, and the "signs" of the animals all around the heaps of broken shells—in this case always perforated on one particular side. Mr C. E. Wright[7] has also sent me an account of one eating a dead mussel which he observed himself, and he has also watched another fishing for water snails (*Limnæa stagnalis*), one of which was devoured in his presence.

A quite exceptional observation is that of Mr Charbonnier, who saw a Water Rat trying to drag into the river Trym a young rabbit larger than itself. Mr Charbonnier does not, however, think that the Water Rat had any intention of eating the rabbit, which screamed and escaped.

Water Rats are exclusive animals. A Brown Rat, if captured alive and caged with others of its species, usually—

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[1] In Millais, ii., 295.

[2] *Field*, 16th July 1887.

[3] *Field*, 17th January 1903, 110.

[4] *Zoologist*, 1849, 2887.

[5] *Journ. cit.*, 1850, 2638.

[6] *Op. cit.*

[7] Wright observed a fight between a Brown Rat and a large crayfish, in which the latter by getting its pincers around the mammal's throat became the victor; and Adams has known Brown Rats to eat crayfish frequently. It is not always possible to distinguish the work of these two rodents, but undoubtedly the cap sometimes fits the Water Rat.

unless enraged by being hurt—makes its entry quite peaceably, and receives all further captives in a tolerant spirit; but a freshly caged Water Rat, like a Lemming, expects to be attacked, and generally has a short bout with all its fellow-captives in turn,[1] thus indicating that it lives in colonies or pairs each in its own territory apart from its neighbours. Of course when the colonies become crowded the sense of "property" indicated above cannot be so readily satisfied, but where the animals are not common, and during the breeding season, they have distinct "beats," as observed on the river Mole, near Reigate, by Mr Adams. These beats extend for about 20 yards along both banks, and the entrance of a stranger is always vigorously resisted, even by immature individuals whose riparian property is invaded. This sense of property rather interferes with the animal's character in captivity, since although naturally gentle and unaggressive, it bites furiously if its nest or its person are interfered with, and cannot be handled unless thoroughly familiar with its owner.

Although "plagues" of Water Rats are not frequently reported, there is evidence that the numbers of these animals are subject to the same extraordinary fluctuations as those of Grass Mice.[2] J. L. Knapp relates[3] that a large stagnant piece of water was thus suddenly infested one summer with an astonishing number, where none had previously been known; they disappeared in the following winter. Mr O. V. Aplin commenting[4] on their varying numbers in Oxfordshire, suggests that many perish during hard winters. Early in 1896[5] a serious "plague" was reported from Read's Island, consisting of some 600 acres of reclaimed pasture in the Upper Humber adjoining South Ferriby, Lincolnshire. This is said to have been reduced to the conditions of a rabbit warren by the burrowing propensities of the animals, which were described as "quite equal to that of the mole." Their food is stated to have been chiefly the roots of grass and thistles, quantities of which were found as if stored in the runs. Eventually the island was flooded by order of the owners, the Humber conservators, but probably the "plague" would have disappeared in the usual way. Judging from contemporary accounts it was three or four years coming on.

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[1] Cocks, *MS.*

[2] As also in Norway, where, however, Collett reports that the increase is chiefly local, and is coincident with that of *Microtus* and *Lemmus.* In Scotland, also, Service (*Annals Scott. Nat. Hist.*, 1896, 206) noted a marked increase during the "vole plague" of 1891-3.

[3] *Journal of a Naturalist*, 1829, 142.

[4] *Zoologist*, 1891, 304.

[5] See R. Payne-Gallwey, *Field*, 22nd February 1896, 294; F. Boyes, *Journ. cit.*, 29th February 1896, 336; also, *Eastern Morning News* of same date.

There is some disagreement as to whether the Water Rat accumulates winter stores of provisions, this habit not having been recently reported. The only positive evidence consists of the statement[1] by Gilbert White that a neighbour when ploughing a dry chalky field, removed from any water, "turned out a Water-rat, that was curiously laid up in an hybernaculum, artificially formed of grass and leaves. At one end of the burrow lay about a gallon of potatoes, regularly stowed, on which it was to have supported itself for the winter." The occurrence puzzled White, and since there is no evidence that he ever examined the rat himself, one is tempted to identify the store with that of a Brown Rat and to mark the identification as a mistake. Fleming, commenting on the above anecdote, remarked that he had twice witnessed the same thing, but since he seems to have believed that Water Rats hibernate in winter, the addition of a store is easily imaginable. On the other hand, since Collett states that such stores of potatoes and other food are usual in the Norwegian *A. terrestris*, it is probably right to regard the observations as correct descriptions of a habit rarely developed in mild climates.

The voice of the British Water Rat has not been described, but M. Lataste mentions that his continental captives emitted a small sharp cry and hissed. Adams caught one alive which emitted "low whistling squeaks" while struggling to escape; these sounds would have been inaudible at a distance of two or three yards.

The eyesight is probably poor, and M. Lataste suggests that all "voles" suffer from myopia. He thus accounts for the fact that a captive, finding itself accidentally on the balcony of a room high above a street, deliberately precipitated itself into space. M. Lataste suggests that it is a like bad eyesight that renders the microtines generally such easy victims of pit-traps.

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[1] Letter xxvi. to Thomas Pennant, 8th December 1769.

The British Water Rat has not been frequently tamed, but M. Lataste kept specimens of two continental forms,[1] some of the peculiarities of which have been mentioned above. Mr English[2] has also caged them; though thriving well in captivity, they are rather troublesome, requiring a large tank of water,[3] which they immediately soil with their droppings and making their cage and nest constantly wet after their aquatic excursions. Cocks has also frequently caged numbers of them, but for the above reason he has never kept them systematically, but has always used them as required, as very suitable food for Wild Cats. Some of M. Lataste's captives showed a tendency to arrange their bed near the water in such a position that they could drop into that element unseen if disturbed; although very assiduous in working at their nest they evidently felt most secure in the water.

The intelligence of the Water Rat is considerable, and it is capable of recognising particular persons; but in the opinion of M. Lataste it is in this respect inferior to the Brown Rat.

The maximum age attained in the London Zoological Gardens is 16 months,[4] but the natural life of the animal is probably much longer.

Sub-family *Murinæ*.

Characters:—The members of this sub-family, the typical mice and rats, are of varied external appearance and habits. They differ from the *Microtinæ* chiefly in being more perfectly adapted for gnawing; in retaining a preference for, and consequently a dentition suitable to the treatment of, a soft and succulent diet; and in leading more active and less earthbound lives. Their eyes and external ears are always well developed.

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[1] *A. sapidus* and *A. scherman*.

[2] In Millais, ii., 293, etc.

[3] If not allowed to swim their eyes become closed by secretion of an oily matter drying like white wax (English).

[4] P. Chalmers Mitchell.

The principal muscles of mastication are the deep portions of the *masseteres laterales;* the temporal muscles are small, and their anterior portions show no tendency to increase in size and strength as in *Microtinæ.* In the **skull**, therefore, the lower maxillary roots of the zygomata, in order to accommodate the enlarged *masseteres laterales* muscles which rise from their outer surfaces, have grown into deep vertical plates of bone which project more or less considerably in advance of the slender upper roots of the zygomata which bridge the infraorbital canals; the numerous specialisations, which in the skulls of *Microtinæ* are the outcome of hypsodont cheek-teeth and exceptionally developed temporal and pterygoid muscles, are wholly lacking; the tympanic bullæ are usually small relatively, and of simple structure, being without internal spongy tissue. The slender **mandible** has usually well-developed coronoid and angular processes.

The **incisor teeth** are, in transverse section, deeper than broad, instead of broader than deep as in *Microtinæ:* this difference of shape is an expression of the greater powers of gnawing possessed by *Murinæ,* in which these teeth are used as gouges, as compared with *Microtinæ,* in which the incisors have the function of cutting or shearing instruments (*cf.* Ryder, *Proc. Acad. Nat. Sci. Philadelphia,* 1877, 314).

The **cheek-teeth** are brachyodont and rooted; their crowns are composed in the most primitive forms of three longitudinal rows of tubercles, each row consisting primitively of at least three tubercles. The axis of each tubercle is more or less oblique to the base of the tooth; in upper molars the tubercles and their grinding surfaces have a general backward inclination, while those of lower molars are inclined forwards. In mastication there is thus little if any longitudinal motion between the upper and lower tooth-rows. The enamel thins out towards the summit of each tubercle and, even in unworn germs, does not cover the dentine at the apex (Hensel, *Zeitschr. deutsch. geol. Gesellsch.,* 1856, 283).

In order to give a clear view of the meaning of the variations in the structure of the cheek-teeth of the *Murinæ* and to facilitate their description, the cusps are numbered or lettered in accordance with the system of notation employed by Hinton.

This system is based upon the work of Winge, Fleischmann, Osborn, Forsyth Major, and Hinton[1]; it is illustrated in Plate XXVIII., in which cheek-teeth of *Cricetinæ*, *Microtinæ*, and *Murinæ* are comparatively represented.

In upper cheek-teeth the tubercles of the median row (*x*, *y*, *z*) are usually conspicuously larger than those of the outer or inner rows; those of the inner row have their axes more nearly vertical than have those of the outer and median rows, and in the various sub-families and individual genera of *Muridæ* this row of tubercles has suffered numerical reduction to a more marked extent than have the others. In *Apodemus*, for example, m^1 has three inner tubercles (Pl. XXVIII., Fig. 4, *x'*, 6, 7); in *Epimys* this tooth has two, cusp 7 being lost; and in *Dendromyinæ*—an African group—only cusp 6 remains. The upper cheek-teeth of *Cricetinæ* (see above, p. 383) have but two rows of tubercles, but in their case the absence of a distinct third row is due apparently to the slight development of the median series, and not to a reduction of the inner row (Pl. XXVIII., Fig. 1).

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[1] Winge (*Vid. Med. Nat. For. Kjöb.*, 1882, 15) came to the conclusion that three cusps, numbered by him from before backwards, 1, 2, and 3, which are prominently developed upon the outer sides of upper and the inner sides of lower molars in some Marsupials, Insectivora, and Chiroptera, are the most ancient elements of the mammalian molar; he identified their homologues, or worked out their fate, in the teeth of other mammalian orders. Two other cusps, internal in upper, external in lower teeth to cusps 1, 2, and 3, were regarded by Winge as later additions, and were numbered as 4 and 5. Here, according to Winge, the development of the lower molars stopped; but in the upper teeth, internally to cusps 4 and 5, two new ones, 6 and 7, successively appeared. In his great papers on the *Lagomorpha* (*Trans. Linn. Soc.*, *Zool.* [2], vii., 433, Nov. 1899), and on the genus *Brachyuromys* (*Proc. Zool. Soc.*, 1897, 695), Forsyth Major adopted Winge's notation for the cusps of upper molars; but he recognised the fact that the evolution of the lower molars is in a *more* and not a *less* advanced stage than is that of the upper teeth—a result confirmed by Stehlin's researches upon the dentition of the pigs (*Abhand. Schweiz. Palæont. Gesellsch.*, xxvi., 22 *et seq.*, 1899). Forsyth Major was therefore able to identify in lower molars the homologues of the cusps 6 and 7 of the upper ones; in addition he took into account some other elements not recognised by Winge, viz., the "intermediate" tubercles.

It has long been known that the inner and outer sides of upper molars correspond respectively with the outer and inner sides of the lower teeth; Fleischmann (*Sitzungsber. Preuss. Akad. Wiss. Berlin*, 1891, ii., 891) went a step further and asserted that the anterior and posterior ends of upper molars are respectively homologous with the posterior and anterior ends of the lower cheek-teeth; a lower molar is therefore a completely inverted image of an upper one. This view was contested by Osborn (*Bull. Amer. Mus. Nat. Hist.*, 1892, 84), but it has been endorsed by Forsyth Major (*Proc. Zool. Soc.*, 1893, 201), and it is supported by Hinton's work. Forsyth Major thought that the cheek-teeth of rodents were derived by a process of simplification or reduction from a multituberculate prototype, and in this he is followed by von Méhely and Hinton. The latter, in his system of cusp notation, takes notice of some ancient elements of the rodent molar which, hitherto, have escaped recognition, and gives effect to the results of all the work briefly reviewed above.

The presence of these three rows of tubercles in the upper molars of *Murinæ* is a fact of high zoological interest, and has given rise to much discussion. Some authors such as Tullberg (*Nagethiere*, 1899, 446) have regarded the inner row as a new addition to the mammalian molar. Winge (*Vid. Med. Nat. For. Kjöb.*, 1881, 17, and 1882, pl. iii., fig. 10*b*), on the other hand, homologises two of the inner tubercles with the cusps, which he numbers as "6" and "7"[1] or the equivalents of the "proto-" and "hypo-cones" of trituberculy; he regards the median and outer rows as simply the result of cleavage of the outer tubercles which are normally present in mammalian molars but which have been specially enlarged in those of *Murinæ*. What, for reasons which cannot be discussed here, is probably the correct view of this latter matter has been put forward independently by Osborn (*Proc. Amer. Assoc. Adv. Sci.*, xlii., 203, 1893) and Forsyth Major (*Proc. Zool. Soc.*, 1897, 714); these regard the median row of tubercles as the enlarged representatives of those molar elements which in other placentals are called "intermediate" cusps, which comprise the "proto-" and "meta-conules" of trituberculy. Both writers thus agree with Winge that the inner row comprises ancient and normal elements of the mammalian molar. Winge regards the postero-internal tubercle of the m^1 of *Apodemus* (Pl. XXVIII., Figs. 4-6, "7") merely as a new offshoot from the postero-median tubercle—*his* cusp "5"; but Thomas (*Ann. and Mag. Nat. Hist.*, January 1906, 84) has argued with right that, occurring as it does not only in *Apodemus* but in many quite distinct murine genera now isolated in such remote corners of the Old World as Australia, the Philippines, Celebes, New Guinea, and Africa, this tubercle must be regarded as an ancient element also, and not as a new addition; and Hinton now homologises it with the cusp which, in the teeth of *Microtinæ*, is numbered by Winge himself as "7" (Pl. XXVIII., *cf.* Figs. 2-7). This view is in complete accord with the results obtained in *Microtinæ*, where in addition to cusp 7 other ancient elements (n, n^1) are sometimes present though they have not yet been found in the teeth of living *Murinæ*. The results in question fully support the theory of a multitubercular origin of the rodent cheek-tooth postulated by Forsyth Major, and are in complete conflict with the tritubercular theory of Cope and Osborn.

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[1] These are the cusps numbered x' and 6 respectively in Pl. XXVIII., Figs. 4-10*a*.

The lower cheek-teeth are in one way more modified than the upper ones; the outer row of tubercles corresponding to the inner row of the upper teeth is so reduced that it has been either completely ignored or else treated as a mere cingulum by all writers except Tullberg. In *Apodemus* and many exotic genera this third row is comparatively well-developed, and consists normally of three tubercles in m_1; it has, on the other hand, completely vanished from the teeth of *Mus* and many other genera; throughout the sub-family it shows the high degree of variability which is characteristic of vanishing structures. From the circumstance that it is a marked feature of the teeth of *Apodemus* and some other *Murinæ*, that it forms an important part of the teeth of some *Microtinæ*, e.g. *Dicrostonyx* (Pl. XXVIII., Fig. 2), and occurs ephemerally in the young teeth of still more remote relatives, e.g. *Spalax* (Méhely, *Species Generis Spalax*, 1913, 305, fig. 10), and from the fact that it comprises such ancient and well-known molar elements as the "proto-" and "hypoconids" of trituberculy, we may conclude that this third or outer row of tubercles was an important feature in the lower molars of the ancestral *Muridæ*. It has suffered reduction and even obliteration in consequence of the hypertrophy of the "intermediate" cusps of the teeth of these remarkable rodents.

Two other elements of the lower cheek-teeth deserve notice. In m_1 and m_2 a posterior "accessory" tubercle (Pl. XXVIII., Figs. 4-10) is almost constantly present in *Murinæ*; this structure appears to be the homologue of part of the posterior transverse loop of the corresponding teeth in *Microtinæ*. In most species of *Apodemus*, and in some other murines, m_1 has an anterior "accessory" tubercle which appears to represent the anterior loop of the m_1 of *Microtus*.

Because of their forward position in the jaws the greater share of the work of mastication falls upon the anterior cheek-teeth above and below, and therefore throughout the sub-family (as in other *Muridæ*) $m\frac{1}{1}$ are the largest and most complex or conservative teeth of the series; $m\frac{2}{2}$ are much smaller, and certain of the cusps, present in the forward part of m_1, are not developed; because of their posterior position and consequent slight mechanical importance $m\frac{3}{3}$ are greatly reduced both in size and in the number of their constituent tubercles, and in several murines these teeth are even entirely suppressed.

The skin of the **tail** becomes detached very readily in some species, *e.g.* in *Apodemus sylvaticus*, being, perhaps, like the brittle tail of dormice (see above, ii., 350), a safeguard against capture by enemies.[1] A mouse which has "escaped by the skin of its tail" generally eats down the injured appendage until it reaches the point where the skin parted.

The sub-family contains, according to Miller, about fifty described genera, four of which occur in Britain. Its members are **distributed** naturally throughout the Old World, with the exception of Madagascar and New Zealand; species of the genera *Epimys* and *Mus* have, as parasites upon humanity, acquired a secondary distribution of world-wide exent.

Murinæ are first known from the Upper Miocene of Europe, and the Pliocene of India; they must have **originated** in the Old World somewhere to the south of the temperate regions, reaching the latter too late to find their way to North America.

GENUS APODEMUS.

1829. APODEMUS, Jakob Kaup, *System der Europaischen Thierwelt*, i., 150 and 154; based on *Mus agrarius* of Pallas, *Novæ Species Quad. e Glirium*, 1779, 95, described from Berlin, Germany; Thomas, *Ann. and Mag. Nat. Hist.*, May 1908, 447 (part); Miller, *Catalogue*.

1905. MICROMYS, Oldfield Thomas, *Ann. and Mag. Nat. Hist.*, May 1905, 492 (part).

Mus of most writers prior to Thomas, 1905, quoted above.

Synonymy and classification:—The subdivision of the large and unwieldy genus *Mus* is a constant object of systematists. Most recent arrangements seem to have originated with Hensel, who in 1856 (*Zeitschr. deutsch. geol. Gesellsch.*, viii., 289) formed two groups, one containing *norvegicus*, *rattus*, and *musculus*, the other *sylvaticus*, *agrarius*, and *minutus*. Hensel's work, although much neglected or overlooked, was supported by Forsyth Major in 1884 (*Atti Soc. Tosc. Proc. Verb.*, iv., 129) and Thomas in 1905, the latter using *Micromys* to include *sylvaticus*, *speciosus*, *minutus*, *mystacinus*, *agrarius*, *harti*, and *geisha*. In 1908 Thomas substituted the earlier *Apodemus* for *Micromys*, and in 1912 Miller restricted the name to *agrarius*, *sylvaticus*, *epimelas*, and their allies, the genus *Micromys* being restricted to the Harvest Mouse (*Mus minutus* of Pallas) and its allies.

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[1] Some exotic *Murinæ*, e.g. *Acomys* (see Bate, *Ann. and Mag. Nat. Hist.*, June 1903, 566), have also very brittle tails, but this does not seem to be the case with any British species.

Characters:—The mice of this genus are rather generalised, and not markedly modified by specialisation in any particular direction. Their ears have no special meatal valves: their tail is not prehensile. They have six or eight mammæ, of which two pairs are inguinal, and one or two pairs pectoral. Their skull has the rostrum well developed, so that, unlike that of *Micromys*, the diastema is distinctly longer than the cranial depth at the anterior root of m^1; the palatal shelf is squarely or roundly notched behind by the posterior nares, though sometimes provided with a short central spinous process; m^1 and m^2 are complex, having three cusps on their inner sides (Pl. XXVIII., Figs. 4-6, x', 6, 7).

The genus is widely **distributed** in arctic, boreal, and transitional regions of the Old World, from Ireland to Japan, and from northern Skandinavia and corresponding latitudes to the Barbary States of North Africa, Palestine, Persia, and northern India. It is absent from Kamtschatka. It is first known from the late Pliocene (Forest Bed) of England, and is evidently of Old World **origin**.

The complexity of the cheek-teeth is a primitive character which assigns to *Apodemus* the lowest **status** among European *Murinæ*. The combination of such cheek-teeth, non-prehensile tail, and normal skull is quite distinctive amongst Palæarctic genera, and is not exhibited by any Oriental or Australian species. Some African mice (*Thamnomys*, Thomas, *Ann. and*

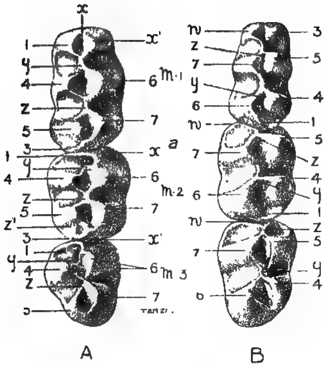
Mag. Nat. Hist., January 1907, 121), however, show a similar combination of characters, perhaps indicating relationship with *Apodemus*, but for Eurasian mammals the genus is a useful and practical institution.

Although not apparently capable of wide variation from the generic type, these mice show, nevertheless, great plasticity before the moulding influences of their environment. Considering the wide range of the genus, the number of its **species** is relatively few; but most of these species are differentiated into numerous sub-species, which are to be regarded as purely local developments or adaptations. The characters which betray this plasticity are principally those of the pelage, coloration, and the proportions of the peripheral organs; the size and form of the skull, and, to a lesser degree, of the teeth are also subject to local modification.

In the **A. sylvaticus** group, to which all the British forms belong, the fur is typically soft, the darker hairs of the back are diffusely distributed and mingled with lighter ones, and the general colour of the upper parts is russet or tawny in more or less sharp contrast with the light belly. The ears, tail, and limbs, particularly the feet, are relatively long. There are six mammæ, the anterior pectoral pair being absent. The skull is always without supra-orbital beads. The cheek-teeth have the outer and inner rows of tubercles relatively well developed; cusp 1 is present in both m^1 and m^2; cusp 7 is well developed in m^3; the outer "accessories" of m_1 are rather large and include vestiges of cusps 6, 7, and *n*. The British representatives of this group are:—

A. sylvaticus, Britain, Ireland, and many of the smaller islands (including Skye and Bute).
A. hebridensis, Hebrides (exclusive of Skye and Bute).
A. hirtensis, St Kilda.
A. fridariensis, Fair Isle and Mid Yell, Shetlands.
A. flavicollis, South Britain.

Of these forms *A. sylvaticus* shows a tendency to split up into several local races or sub-species within the British area. *A. hebridensis*, *hirtensis*, and *fridariensis* may be regarded as local developments from the primitive *sylvaticus* stock of the region, which appear to have resulted from the segregation of this stock upon small islands; the characters which distinguish them from the parent stock are slight, and all three might well be regarded as mere sub-species of *sylvaticus* were it not for the fact that *hebridensis* and *fridariensis* have in turn undergone a further differentiation into a number of quite recognisable and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5
3
x
a
1
y
4
6
m·2
z
7
5
z'
3
x'
1
y
6
m 3
4
z
7
5
TERZI
A
n
3
z
5
7
y
4
6
n
1
5
7
z
6
4
y
n
1
z
7
5
y
4
6
B

FIG. 1.

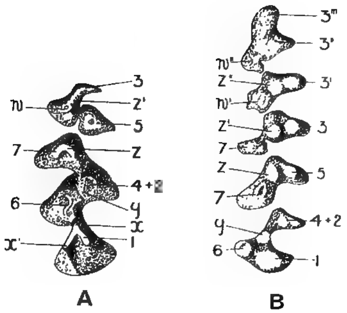
3
n
z'
5
7
z
4+2
6
y
x
x'
1
A
3''
3'
n''
z'
3'
n'
z'
3
7
z
5
7
y
4+2
6
1
B

FIG. 2.

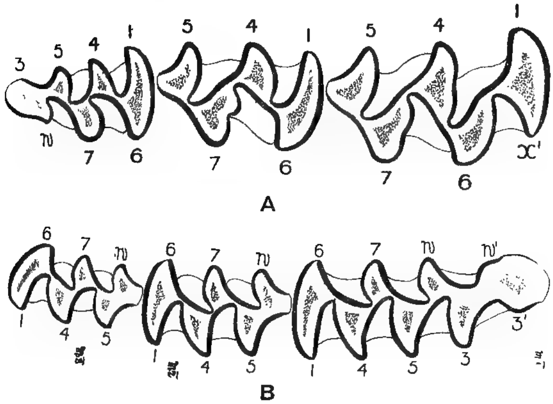
3
5
4
1
5
4
1
5
4
1
n
7
6
7
6
7
6
x'
A
6
7
n
6
7
n
6
7
n
n'
1
4
5
1
4
5
1
4
5
3
3'
B

FIG. 3.

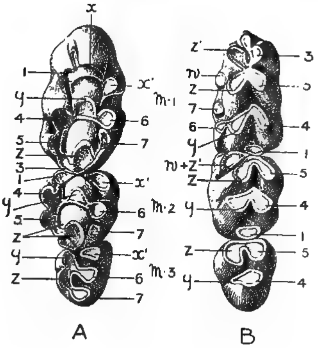
x
1
x'
m·1
y
4
6
5
z
7
3
1
x'
4
y
6
5
m·2
z
7
y
x'
z
6
m·3
7
A
z'
3
n
5
z
7
6
4
y
1
n+z'
5
z
m·2
y
4
1
z
5
y
4
B

FIG. 5.

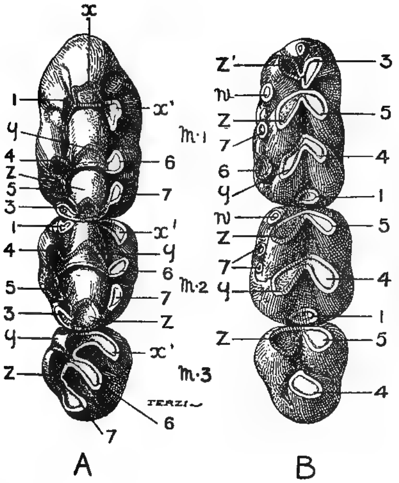
x
1
x'
m·1
y
4
6
z
5
7
3
1
x'
4
y
6
5
m·2
7
3
z
y
x'
z
m·3
TERZI
7
6
A
z'
3
n
5
z
7
4
6
y
1
n
5
z
7
4
y
1
z
5
4
B

FIG. 4.

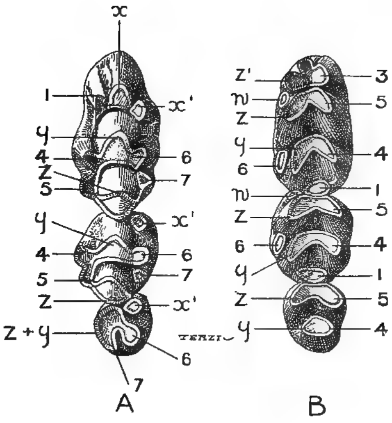
x
1
x'
y
4
6
z
7
5
y
x'
4
6
5
7
z
x'
z+y
TERZI
6
7
A
z'
3
n
5
z
y
4
6
n
1
z
5
6
4
y
1
z
5
y
4
B

FIG. 6.

For explanation of Figures, see overleaf.

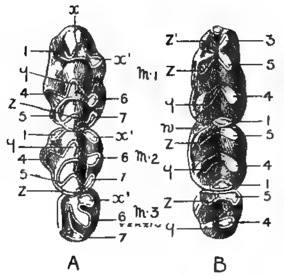
x
1
y
4
z
5
1
y
4
5
z
x'
m·1
6
7
x'
6 m·2
7
x'
6 m·3
7
TERZI
z'
z
y
w
z
y
z
y
3
5
4
1
5
4
1
5
4
A
B

FIG. 7.

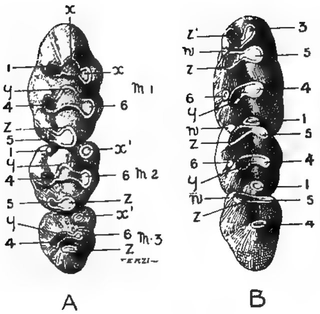
x
1
y
4
z
5
1
y
4
5
y
4
x
m 1
6
x'
6 m 2
z
x'
6 m·3
z
TERZI
z'
w
z
6
y
w
z
6
y
w
z
3
5
4
1
5
4
1
5
4
A
B

FIG. 8.

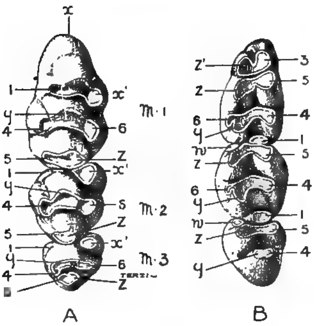
x
1
y
4
5
1
y
4
5
1
y
4
x'
m·1
6
z
x'
5 m·2
z
x'
6 m·3
z
TERZI
z'
z
6
y
w
z
6
y
w
z
y
3
5
4
1
5
4
1
5
4
A
B

FIG. 9.

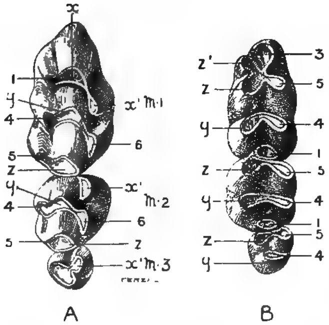
x
1
y
4
5
z
y
4
5
x' m·1
6
x'
m·2
6
z
x' m·3
TERZI
z'
z
y
z
y
z
y
3
5
4
1
5
4
1
5
4
A
B

FIG. 10.

EXPLANATION OF FIGURES.

CROWN VIEWS OF SLIGHTLY WORN CHEEK-TEETH OF MURIDÆ.

a, RIGHT UPPER TEETH; *b*, LEFT LOWER TEETH.

All the figures, with the exception of Figs. 2 and 3, *are from Miller's "Catalogue of the Mammals of Western Europe" (by kind permission of the Trustees of the British Museum).*

Fig. 1.—*Cricetus cricetus* (five times life size).
„ 2.—*Dicrostonyx* sp., m^1 and m_1 (ten times life size), of a very young animal from Floeberg Beach, Grinnell Land (B. M., 78.5.13.1).
„ 3.—*Arvicola amphibius* (seven times life size).
„ 4.—*Apodemus epimelas* (ten times life size).
„ 5.—*Apodemus sylvaticus* (ten times life size).
„ 6.—*Apodemus agrarius* (ten times life size).
„ 7.—*Micromys minutus* (ten times life size).
„ 8.—*Epimys rattus* (five times life size).
„ 9.—*Epimys norvegicus* (five times life size).
„ 10.—*Mus musculus* (ten times life size).

The homologous cusps of upper and lower cheek-teeth are similarly lettered or numbered in the figures. In upper teeth cusp 6 equals the "protocone" of trituberculy (*cf.* Vol. I., Pl. II., Fig. 1A); 7 is the "hypocone"; 4 and 5 are the "para-" and "meta-cones"; 1 and 3 are the "para-" and "meta-styles"; and *y* and *z* are the "proto-" and "meta-conules" respectively. In the microtine tooth (Fig. 2*a*) the cusps marked 4, 5, 6, and 7 correspond with those so numbered by Winge in upper teeth of *Evotomys* and *Microtus* (*Danmarks Pattedyr*, pp. 70, 77, Figs. 27*b*, 30*b*). In *Murinæ*, Winge regards the cusps here called x^1 and 6 as the homologues of 6 and 7 in the *Microtinæ;* he further regards *y* as the major part of 4, and similarly his cusp 5 in this sub-family is a compound of the cusps 5, *z*, 3, and 7 (see *Vid. Medd. Nat. For. Kjöb*, 1882, Pl. iii., Fig. 10*b*, and *Danmarks Pattedyr*, pp. 86, 93, Figs. 33*b*, 42*b*). The view of the homologies expressed in this plate has been gradually arrived at in the course of many years' work upon the dentition of rodents, and with a knowledge of many facts which cannot be discussed here.

The ancient cusp 2 (Vol. I., Plate II., Fig. 1A, *ms*) which, according to Winge, is the homologue of the Reptilian cone, and is, therefore, the true "protocone," is present in the teeth of many low *Muridæ*, e.g. some of the American *Cricetinæ* and the Malagasy *Nesomyinæ*; in all *Microtinæ* and *Murinæ* 2 has fused with cusp 4, and has completely disappeared.

distinct insular races. *A. flavicollis* appears to be a specialised offshoot of the *sylvaticus* group; it is quite likely of Eastern origin, its range extending from northern India to England, in which latter country it is a relatively recent immigrant and has developed as a sub-species, *A. f. wintoni*, distinct from the typical continental form.

The *sylvaticus* group has a wide range, extending over the whole habitat of the genus with the exception of eastern Asia and Japan. This group probably originated in western Europe; it is first known from the late Pliocene (Forest Bed) of Britain, and all the fossil forms hitherto discovered in this country are close allies of *A. sylvaticus*.

A. mystacinus, Danford and Alston (*Proc. Zool. Soc.*, 1877, 279), from Palestine, and *A. epimelas*, Nehring (*Sitz.-Ber. Gesellsch. Nat. Freunde, Berlin*, January 1902, 2), from Greece and the Balkan Peninsula, are much like the *sylvaticus* group in essentials, but differ in their large size and rather more primitive molars, m^1 and m^2 retaining a distinct cusp 3—an ancient element of which no more than the merest trace is normally present in other known species of *Apodemus* (Pl. XXVIII., Fig. 4).

A. geisha, Thomas (*Ann. and Mag. Nat. Hist.*, May 1905, 491), is confined to the Japanese Archipelago, where its typical form occurs on Hondo, Shikoku, and Kiushiu; it is differentiated into distinct sub-species on each of several of the islands to the north or south of the three named. It is described as a delicate species about equal in size to one of the smaller forms of *A. sylvaticus*, but with more of the build and appearance of a large harvest mouse; its soft fur does not become spiny in summer; it has eight mammæ; the skull is very smooth, light and delicate, without supra-orbital beads, and with the masseteric zygomatic plates but little developed; cusp 1 is present in m^2.

A. speciosus, Temminck (*Fauna Japonica*, 1845, 52; described from Japan), is the type of a widely distributed Eastern group which ranges throughout Japan, Korea, Manchuria, and westwards and southwards through China; in central Asia it is represented by *A. nigritalus*, Hollister (*Smiths. Misc. Coll.*, March 1913, 1; described from Tapucha, Altai Mountains, S.E. of Biisk), and it is there accompanied by a member of the *sylvaticus* group (*A. s. tscherga*, Kastchenko). In the *speciosus* group the fur becomes spiny in summer, and there are eight mammæ; the skull has the margins of the inter-orbital region beaded; the cheek-teeth are like those of the *sylvaticus* group. *A. semotus*, Thomas (*Ann. and Mag. Nat. Hist.*, May 1908, 447), is an interesting representative of the *speciosus* group inhabiting the island of Formosa; this is a dark-coloured, thin-furred form which has lost the anterior pectoral mammæ, there being but six as in *A. sylvaticus*, and in which m^1 and m^2 have cusp 7 better developed than in most of the sub-species of *speciosus*.

A. agrarius, Pallas (*Nov. Sp. Quad. e Glir.*, 1778, 95; described from Berlin), the "Brandmaus," is a species with a very wide range, extending from Denmark and Germany across Eurasia to the coast of China and Korea; it is also known to inhabit some of the Asiatic coastal islands, such as Quelpart, but it does not reach Japan; its absence from Britain, Skandinavia, and Iberia is noteworthy. In its typical form this species is characterised by the ochraceous colour of the upper parts, and the middle of the back is clothed with black hairs which form a sharply defined dorsal streak. The tail, ears, and feet are relatively short, and the general form is stouter than in the *sylvaticus* group; there are eight mammæ. The skull has supra-orbital beads as in *A. speciosus.* The cheek-teeth (Pl. XXVIII., Fig. 6) are more highly specialised than are those of other species of *Apodemus*: the median tubercles of the upper teeth are much enlarged at the expense of the outer and inner rows; cusp 1 is much reduced in m^1 and has vanished from m^2; cusp 7 is reduced in m^3. This group has not improbably originated in the East, and it may well be the result of a specialisation of the same stock as that from which *A. speciosus* has descended. In this connection it may be noted that in *A. chevrieri*, Milne-Edwardes (*Rech. Mamm.*, 1868, 288; described from eastern Thibet), a close ally of *A. agrarius*, the fur develops spines in the summer and there is no trace of dorsal darkening. In the Chinese *A. a. ningpoensis*, Swinhoe (*Proc. Zool. Soc.*, 1870, 637), there is little trace of the dorsal streak, while in *A. a. coreæ*, Thomas (*Proc. Zool. Soc.*, 1908, 8; described from Korea and Quelpart Island), it is subject to great variation, and thè summer coat is spiny. Other far-eastern sub-species, *A. a. mantchuricus*, Thomas (*Proc. Zool. Soc.*, 1898, 774), and *A. a. pallidior*, Thomas (*Proc. Zool. Soc.*, 1908, 8; described from the Shantung Peninsula), resemble the European *A. agrarius* in these respects.

THE FIELD MOUSE.[1]

APODEMUS SYLVATICUS (Linnæus).

APODEMUS SYLVATICUS SYLVATICUS (Linnæus).

1758. [MUS] SYLVATICUS, Carolus Linnæus, *Systema Naturæ*, 10th ed., 62; described from Upsala, Sweden; Fleming; Jenyns; Bell (ed. 1 and 2); Turton and practically all authors, except as given below.

1839. MUS INTERMEDIUS, J. C. Bellamy, *Natural History of South Devon*, 195 and 329, and figure; described from Whiteford stables, Devonport, Devonshire.

1900. MUS SYLVATICUS INTERMEDIUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 398; Johnston; Millais; Trouessart.

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[1] Long-tailed Field Mouse or Wood Mouse of some authors.

1900. MUS SYLVATICUS CELTICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 401, pl. xxv., fig. 2; described from Caragh Lake, Co. Kerry, Ireland, and based on an immature specimen of *M. s. sylvaticus;* (type a female, No. 0.3.11.1 of Brit. Mus. collection, taken by Colonel J. W. Yerbury, 27th November 1894); Johnston; Millais; Trouessart.

1900. MUS SYLVATICUS TYPICUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 404.

Skovmus of the Norwegians; *le mulot* of the French; *die Waldmaus* of the Germans.

Synonymy:—The first item refers to the species *sylvaticus;* the remainder to the well-known sub-species common in Britain. As this species is also widely distributed in Continental Europe, it has received many names, but only those referring to British specimens are cited. The full synonymy will be found in Miller's *Catalogue.*

The British synonymy is simple. Unfortunately the common British Field Mouse was at one time considered a recognisable form, for which Bellamy's name *intermedius* became available, but Miller has shown that that is not the case. Unfortunately also, *A. s. celticus* cannot be retained as a distinct form. The synonymy and description of valid local forms is given separately below.

Terminology:—This mouse, the *Mus domesticus medius* of Ray (1693), appears in the earlier subsequent natural histories (Pennant, 1766 and 1768; Berkenhout, 1769) as the "Long-tailed Field Mouse," a term used in opposition to the "Short-tailed Field Mouse" (*Microtus*). In his edition of 1776 Pennant shortened this name to "Field Mouse." He was followed by Fleming and Jenyns; but the longer term was retained as an alternative by Bingley (1809), and exclusively by Donovan (1815-1820). "Wood Mouse," which is evidently a translation of the Latin specific name *sylvaticus*, appeared first in Turton (1807), disappeared until 1837, when it was revived as an alternative, by Bell, from whom it was adopted by practically all subsequent writers, though sometimes with the longer name as an alternative, except Johnston (1903), who reverted to "Long-tailed Field Mouse." The latter term has become too long to apply to all the forms now recognised as distinct from *sylvaticus*, but if the adjective "long-tailed" be dropped, the oldest name for the animal in British zoology thus abbreviated becomes also the most appropriate, "Field Mouse" having its older significance of "Wild" or "Out-of-door Mouse" in contrast to "House Mouse." The name "Wood Mouse," although short, is not nearly so appropriate, the common *sylvaticus* being found in a wide range of habitats.

Local names (non-Celtic):—Many of the names of other animals, *e.g.* shrew and dormouse, are sometimes applied indiscriminately to mice regardless of species. Thus when found in a bird's nest the

Field Mouse may pass for the Dormouse (see Bolam, *Naturalist*, 1913, 41). "Bean Mouse" (sometimes "Beaner") of Pennant (Thompson, iv., 1856, 15) is a word known in Kent, Surrey, and Sussex, from its habit of attacking stores of beans and peas (L. E. Adams, *MS.*).

(Celtic):—Scottish Gaelic—the species of mice are not usually distintinguished, and *luch-fheoir* or *luch-an-fheoir*="grass mouse" is applied indiscriminately in Scottish Gaelic (C. H. Alston). Irish—*Luch fheoir*="grass mouse" of Clare Island (Colgan, *Proc. R. Irish Acad.*, xxxi., 4, 22, 1911). Welsh—*Llygoden y maes* or *Llygoden goch*=Field Mouse; *Llygoden ganolig*=Common Mouse. Manx—*Lughvarghey*, *Lugh sliean* (Millais).

History and status:—A species of *Apodemus* was described by Gesner (*Quad.*, 1551, 830) as *Mus agrestis major.* Although many descriptions were published in the eighteenth and the early part of the nineteenth centuries, a knowledge of the status of these mice cannot be said to have existed prior to the work of Hensel (1856). The status has been discussed above under the genus.

Distribution:—*A. sylvaticus* is distributed over nearly the whole of Europe and a large part of Asia. Its range extends from Ireland and Iceland to central Asia, and from central Skandinavia and northern Russia southwards to Algiers, Sicily, Crete, the mountains of southern Persia, and northern India. In the Alps, according to Blasius, it ascends to 6000 feet. Fatio (p. 212) records it from a height of 1900 metres in the Bernese Oberland, and from 2500 metres in the Engadine[1]: he says that in the bad season it retires from such stations to chalets and the cellars of houses. In the Altai Mountains it is met with up to about 7000 feet; in the mountains of Persia it has been taken at about 5000 feet; and it occurs in the Himalayas up to a height of 11,500 feet.

Miller says: "This is the most abundant and universally distributed of European mammals. Except in cities, at the extreme north, on the highest mountains, and perhaps in some parts of the Mediterranean region, it is probably more numerously represented in individuals than any other species."

The typical sub-species, *A. s. sylvaticus*, which is the common British form, ranges from Ireland across central Europe eastwards for an unknown distance into Russia; and from central Sweden and Norway to the south of France and northern Italy. It occurs also in Iceland, but is generally regarded as an introduction there. Thienemann (*Reise im Norden Europas*, ii., 153) described the Icelandic Field Mouse as a distinct species, *Mus islandicus*, but in habits and character this animal does not appear to differ from typical *sylvaticus* (see Steenstrup,

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[1] These high Alpine Mice were probably *flavicollis*, see p. 546 below.

Vid. Med. Nat. For. Kjöb., 1868, 51; Brown, *Proc. Zool. Soc.*, 1868, 343; Miller, *Catalogue*, 804).

In Britain it is probably, with *Sorex araneus*, the commonest small British mammal, of practically universal distribution; both species are very common in owl's pellets, their numbers being only approached in certain situations by the Grass Mouse, which (Coward and Oldham, *Cheshire*, 273), although preponderating in certain limited areas, is not nearly so widely distributed as the Shrew and Field Mouse. The Bank Mouse is numerous, but also cannot compete with these two (Pocock, *Zoologist*, 1897, 507; Grabham, *ibid.*, 571). Traces of "a colony of some small animals" on the top of Maam Soul, Inverness-shire, at a height of between 3000 and 4000 feet, noticed by the Rev. G. Gordon (*Zoologist*, 1844, 424; A. Hepburn, *ibid.*, 1848, 2010), may possibly refer to this species, but as W. Evans (*in lit.*) points out, the "small animals are more likely to have been 'voles' of some sort." In the Edinburgh district, according to W. Evans, it is common from sea-level to a considerable elevation in woods, fields, and natural pastures, but is more numerous in the plains and warmer valleys than in the damp uplands beloved of *Microtus*.

It is of widespread though less common occurrence in Ireland, and inhabits the islands off the west coast such as Inishmore and Clare. It occurs on Man, Anglesey, Bardsey, Lundy, Skomer, Lambay, Scilly, Wight, and the Channel Islands: it is common on Skye and Bute, but on the latter island its differentiation from the typical form has proceeded so far that it is now given distinct sub-specific rank. Field Mice inhabit Orkney (Barry, ed. ii., 1808), and a form much like typical *sylvaticus* occurs on the mainland of Shetland. Ogilvie-Grant has recently caught specimens of a long-tailed, rather pallid form on Sanday, Orkney; these were taken among the rough grass by the sea. The precise status of the Sanday Field Mouse cannot be settled without further material, but, judging from the skull, it is more nearly related to *sylvaticus* than to *fridariensis*.

Distribution in time:—The *A. sylvaticus* group dates from the late Pliocene (Forest Bed of Norfolk) in Britain, and in the earlier part of the Pleistocene it is known from the High Terrace and the older deposits of the Middle Terrace of the Thames. These older fossils are for the most part very fragmentary, and they prove little more than that the teeth of the earliest British Field Mice were similar in size and form to those of *A. sylvaticus* (Newton, *Vert. Forest Bed*, pl. xiv., fig. 11, a). A maxilla from the High Terrace, at Greenhithe, Kent, shows that in the skull of the form of this horizon (*A. whitei*, Hinton, *Ann. and Mag. Nat. Hist.*, June 1915, 580) the posterior ends of the incisive foramina and the maxillo-palatine suture were a little more forwardly placed than in existing races. The Forest Bed and Middle Terrace forms may eventually prove to belong to *A. whitei* also.

Like the older forms of *Evotomys*, the *Microtus agrestis* group and

Arvicola, *Apodemus* appears to have died out in Britain during the middle Pleistocene, no trace of the genus being found in the later deposits of the Middle Terrace of the Thames. It then reappeared in the late Pleistocene (Ightham stage) by two forms having close affinities with the living *sylvaticus* and *flavicollis* respectively. The *sylvaticus*-like form has been discovered in numerous English cave and fissure deposits of late Pleistocene age; but the remains, although abundant, are not sufficiently perfect to permit of a close comparison with any particular one of the living British members of the group. In Ireland similar fossils have been obtained from the Ballinamintra Cave, Co. Waterford (Adams, *Trans. R. Dublin Soc.*, S. 2, vol. l., 195, 1881, where they are described as frog bones; see Scharff, 184); the caves of Kesh, Co. Sligo, where they were found in all deposits from the superficial brown layer to the basal clay (Scharff, 197); the Edenvale Caves, Co. Clare, where they were fairly abundant in all the caves, both in upper and lower strata (Scharff, 35); and the Newhall and Barntick Caves, Co. Clare, where they were rare and occurred mainly in the upper strata (Scharff, 35). Remains of *A. sylvaticus* are also common in Holocene alluvial deposits and "submerged forests" in England.

Description:—In general form the Field Mouse is much like a House Mouse, but differs in its much longer hind legs, larger hind feet and ears, and in its much larger and far more prominent eyes.

The ears are of a broad ovate form, and extend, when laid forwards, for a short distance beyond the eyes; they are thinly clad with short hairs; the antitragus is represented merely by a feeble ridge. The tail is about equal to the head and body in length; it tapers distally, is somewhat angular in section, and distinctly annulated, there being about 150 rings in all; the tail hairs are short and do not conceal the annulations, though they form a short terminal pencil. The snout is long and very prominent; the nostrils, separated by an upward continuation of the deep median cleft of the lip, open obliquely outwards and forwards, and are wider in front than behind; beneath them the small naked muzzle-pad is bounded by a transverse furrow. In each hand the thumb is a rudimentary tubercle covered by a small nail; digits 2, 3, and 4 are the longest, 3 is slightly longer, 2 distinctly shorter than 4; digit 5 reaches to the base of 4; each finger is armed with a small sharp claw and crossed below by deep transverse grooves, of which there are five or six on digit 3; the palm is naked and provided with five normally placed pads, of which the two hinder are the largest; between the pads the skin is irregularly wrinkled. In each foot the hallux extends to the base of digit 2; the three middle toes are of nearly equal length, digit 3 being, however, slightly the longest; digit 5 reaches distinctly beyond the base of digit 4; the toes are grooved transversely below, there being seven or eight grooves on the central digits; their claws are like those of the fingers. The sole is naked except in the region of the heel, and it is provided with six normally placed pads; the latter though well developed are smaller than those of the palm; they are ovate in form, the postero-external being the smallest; the skin between the pads is finely tuberculo-reticulate, smooth between the last pad and the heel, in which latter situation it is wrinkled. There are six mammæ in the female, one pair being pectoral, the remaining two pairs inguinal. In young males the *glans penis* is complex; the parts called *papilla centralis*, *pp. laterales*, and *p. lingualis* by Tullberg being distinct, as in *Cricetus;* in the adult certain of these elements fuse together, and the *glans* acquires a simpler form approaching that of higher *Murinæ*, e.g. *Epimys* (see Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 133). Each testis when fully developed is as large as, or larger than, the brain.

Pelage:—The fur is soft and never becomes spinous, for though many of the hairs of the back are grooved bristles these are quite weak. The density and length of the fur varies according to the sub-species, age, or season. In English specimens the longer hairs of the back attain a length of about 9 mm. in summer, and 10 mm. in winter.

Colour (*A. s. sylvaticus*):—The basal two-thirds of all hairs, at all ages and seasons, are slate-grey; this tint is concealed by the differently coloured hair tips. The general colour of the back in adults in fresh pelage is "wood-brown," with a more or less distinct reddish tinge posteriorly, and becoming paler or more buffy on the head, shoulders, and flanks. Numerous long black hairs slightly but distinctly cloud the middle of the back with black; on the flanks, where they are fewer, these hairs produce a well-marked "lining" effect. On the cheeks, sides of the neck, outer surfaces of the fore legs, and along a narrow, ill-defined region immediately above the line of demarcation on each side, the colour is a dull light buff. The line of demarcation is always distinct in adults. The whole ventral surface and the dorsal surfaces of the feet are of a dull white or silvery hue, irregularly darkened on the throat and belly by the slaty bases of the hairs, and sometimes washed with buff. A more or less bright spot of buff or orange is frequently present on the throat in well-developed specimens; sometimes this forms a complete collar, or is lengthened into a feeble median stripe; it is often quite minute or wholly absent. The ear is dull brown, with lighter or occasionally silvery edges. The tail is inconspicuously bicoloured, its upper surface being dark brown, whitish below.

Moult:—Specimens showing the moult are rare, and the change of coat is probably made in a gradual and inconspicuous manner (Barrett-Hamilton, *Proc. Zool. Soc.*, 1900, 399). Adams has seen only one case in which the line of demarcation was in moult; this, a young female (H. and B., 73 mm.; perforate) taken at Reigate in June, had the hinder and central part of the ventral surface in the first or grey pelage, while laterally and forwards the thick white adult pelage was developed. A male (B.M., No. 98.2.1.18) from Holland, taken in September by Thomas, is moulting from the rufous to a duller coat, and has just a patch of the former colour on the rump, the rest of the body being dull (Barrett-Hamilton, *op. cit.*, 399).

Young:—The young are duller and more like House Mice in appearance than are the adults; their upper parts have usually a leaden tinge, their bellies are more slaty, and there is no well-marked line of demarcation.

Local variation:—From the evidence afforded by the skulls, discussed below, it is not at all unlikely that tangible local differences of colour exist among the British Field Mice; but a very carefully collected set of summer and winter specimens from several selected localities must be obtained before any attempt at defining such differences can succeed. It was noted that amongst British specimens summer skins from Oxfordshire and Leicestershire were the brightest and reddest; an old nursing female from Glamorganshire, taken in July, was, however, as brightly coloured as any of them. Field Mice from the London Parks are very dark and smoky, as are the birds and Lepidoptera, but in their case the change is doubtless a pathological one. The sub-species *Mus s. celticus*, Barrett-Hamilton (*op. cit.*, 401), was based upon some small dark-coloured specimens from Co. Kerry, Ireland, and similar specimens from this locality were described long ago by Jenyns (*Ann. and Mag. Nat. Hist.*, 1841, June, 268); the typical series, however, are all immature, and do not differ from young individuals of *A. s. sylvaticus*. In a long series taken in Skye by Mr P. D. Montague in March, and by Mr C. H. B. Grant in July (see note on p. 422 above), the backs are rather dark and the ventral surfaces frequently show traces of a median wash of yellow. Specimens from the Highlands also appear to average darker than those from southern England. These Scotch mice make an approach towards the small dark form inhabiting Bute, which, having distinctive skull characters in addition, is described below as a distinct sub-species.

The **skull** (Fig. 89) is lightly built, and of moderate size; its dorsal line is at first straight, rising from the nasal tips to the inter-orbital region, whence it is gently convex to the occiput, the highest point being in the mid-parietal region; its ventral line is nearly horizontal to behind the tooth-rows, and then slopes rapidly down to the level of the lower surfaces of the bullæ. The brain-case is very smooth, of oval or sub-circular form; the upper limits of the temporal fossæ are marked on its sides and shoulders by a very feeble ridge, which on each side is continued forwards into the smoothly squared edge of the hinder part of the inter-orbital region. The inter-parietal is short, but very wide; its lateral extremities are drawn out as pointed processes which approach the squamosals, and it is wholly posterior to the straight lambdoid suture. The inter-orbital region is moderately constricted, about equal in width to the hinder part of the rostrum. The zygomatic arches are very slender, with delicate splint-like jugals; they are but slightly expanded, and drop rapidly from their maxillary roots to the alveolar level. The inferior zygomatic process of the maxillary is a massive plate, the vertical anterior border of which projects considerably in advance of the slender bridge-like upper process. The nasals are long and slender; they project noticeably in advance of the incisors, and are supported anteriorly on blade-like processes of the premaxillaries. The diastema is nearly twice as long as the tooth-row; the incisive foramina are long and reach back to a point opposite the front of m^1. The palate is flat; the maxillo-palatine suture does not reach further forwards than opposite the hinder part of m^1. The ecto-pterygoid plates are well developed; the pterygoid fossæ are shallow and slope backwards from the level of the palate to that of the basi-sphenoid; the inter-pterygoid space is long, narrow, and rectangular. The hamular processes curve outwards behind, and are in contact with the eustachian expansions of the small rounded bullæ; each bulla has a large meatus, the rim of which is slightly tubular. The basi-occipital is of moderate width, with a low median ridge and shallow lateral depressions; the paroccipital processes are very small; the body of the presphenoid is reduced in part to a thread of bone.

Adult skulls from different parts of the British Isles show, when carefully examined, slight but quite tangible differences of form and proportion, which indicate the tendency of the Field Mouse to develop races adjusted to the requirements of purely local conditions. Compared with skulls from central and southern England, those from Wales are slightly deeper and narrower, with smaller bullæ and slightly shorter post-molar and diastemal lengths; those from the lowlands of Scotland are relatively narrower throughout, with more depressed brain-cases and rather small bullæ; those from the Highlands are small, with slightly larger brain-cases, wider nasals, longer diastemata, and incisive foramina. Irish skulls agree more closely with those from England and Wales than with those from Scotland. Those from Man have slightly deeper brain-cases and longer palates. On Clare Island and Inishmore the skull seems to be considerably larger than usual, and this is the case also on Alderney and Scilly. Skulls from Jersey agree with the largest English specimens in size, but in several of their relative proportions they resemble those of the Scotch Highlands. For further details and summary of relative dimensions, see Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 118, and the table at p. 518[1] below.

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[1] The measurements in this table (and those in that at p. 538) were made with great care and good instruments. The skulls measured were in all cases adult, the cheek-teeth being *at least* half worn.

The mandible is slender, with small but well-developed coronoid and long, rather slender, angular processes; the dental foramen is level with the alveoli; the incisor roots produce a small external projection at the base of each coronoid process.

Cheek-teeth are typical of the *sylvaticus* group, and have been described above under the genus (p. 504, Pl. XXVIII. Fig. 5.)

Exceptional variation:—Melanism appears to be very rare. Millais (*Mamm.*, 197) mentions one "perfectly black," shown by Borrer to Harting, but the specimen was not forthcoming; a "black and white" field mouse, which attracted notice by "producing a chirping noise," is recorded by R. P. Williams (*Proc. Dublin Nat. Hist. Soc.*) in *Nat. Hist. Review*, v., 1858, 188. A good many completely or partially albinic individuals have been recorded, *e.g.*, (1) one from Highwood, Middlesex (Cox, *Field*, 18th January 1873, 51); (2) a pink-eyed nursing female, Great Marlow (Cocks, *Zoologist*, 1884, 226); (3) pale buff, Broxton, Cheshire, in Grosvenor Museum, Chester (Newstead, *Chest. Soc. Nat. Sci. and Lit. Proc.*, iv., 249); (4) (Forrest, *Zoologist*, 1910, 307); (5) three cream-coloured in J. Whitaker's collection; (6) "young albino," Montgomeryshire (Forrest, *MS.*); (7) a buff female, black hairs entirely absent, from Brent Knoll, Somerset (No. 3.12.17.1 of British Museum collection, Percival); (8) male, silvery grey without reddish tints, alive with Laver (*lit.*, 22nd October 1905). Such cases cannot, however, be said to be common; Laver (*lit.*, 9th April 1904) said that he had only seen one, out of a thousand examined. Adams says:—"The only albinism I record is at the tip of the tail (twice)."

Geographical variation:—In addition to the typical form, four distinct sub-species are now recognised in Europe. These are:—(1) *A. s. butei*, Hinton, from the island of Bute, Scotland, described below; (2) *A. s. callipides*, Cabrera (*Bol. Real. Soc. Españ. Hist. Nat.*, Madrid, vii., 227, November 1907), a large dark-coloured form, in which the hind foot frequently measures 23 mm., while the condylo-basal length is 23·6 mm. or more, inhabiting the mountains of the Pyrenees-Asturias chain, and ranging southwards into Portugal; (3) *A. s. dichrurus*, Rafinesque (*Précis des Découvertes Somiologiques*, 1814, 13), which agrees with *callipides* in size, but differs from both it and true *sylvaticus* in its pallid and dull coloration, due to the suppression of the rufous and the predominance of the yellow and grey tints; this mouse was described from Sicily, and it inhabits the Mediterranean region from the Balkan Peninsula to central and southern Spain; (4) *A. s. creticus*, Miller (*Ann. and Mag. Nat. Hist.*, November 1910, 460), a mouse no larger than true *sylvaticus*, but of pale and more yellowish colour, which is known only from the island of Crete. A considerable number of sub-species have been described from Asia; of these the more conspicuous are:—*A. s. tauricus*, Barrett-Hamilton (*Proc. Zool. Soc.*, 1900, 412), from Asia Minor, a small form in which the total length of the skull is no more than 23 mm.; *A. s. witherbyi*, Thomas (*Ann. and Mag. Nat. Hist.*, December 1902, 490), described from the mountains (5200 feet) near Sheoul, Fars, southern Persia, a desert race with pale grey upper side, pure white belly, and small teeth; *A. s. arianus*, Blanford (*Journ. cit.*, 1881, 162), similar to the last in appearance, but with larger teeth; this mouse was described from Kohrud, between Ispahan and Teheran, Northern Persia, where it was found at a height of 7000 feet; Thomas (*Ann. and Mag. Nat. Hist.*, March 1909, 262) records it from the hills round Samarkand, Turkestan; *A. s. tscherga*, Kastchenko, is a small sub-species with a relatively short tail, inhabiting the Altai Mountains, Central Asia; *A. s. pentax*, Wroughton (*Journ. Bombay N.H. Soc.*, April 1908, 283), from the northern Punjab, is characterised by its short tail and narrow skull; lastly, *A. s. wardi*, Wroughton (*op. cit.*, 282), which occurs at a great elevation (9000-11,500 feet) in the mountains of Kashmir, a drab-coloured form, is worthy of mention. The North African forms are referred to two sub-species, *A. s. hayi* (Waterhouse) from Tangier, Morocco, and *A. s. algirus*, Pomel.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 5th Sept. 1912, average of 6, 1 to 2 days old; quite naked and blind, ears under skin, umbilical scar	32	11	6	..	1·7
2. 28th April 1912, caught in the open; first pelage, eyes open	58	43	18	5	4
3. 15th Sept. 1912, average of 5; eyes open, suckling in nest	56	44	17	7	7
4. 26th Oct. 1912, male; first pelage. .	60	55	20	13	7
5. 24th Sept. 1900, female; first pelage .	61	67	20	..	..
6. 28th Sept. 1913, male; juvenal pelage below	65	67	19·5	12	7·5
7. 6th Nov. 1911, female; first pelage .	68	71	21	13	8·5
8. 14th Oct. 1913, female; juvenal pelage below	72	70	21	15	12
9. 7th June 1912, female; changing from grey to white below	73	67	21	14	11
10. 11th Aug. 1909, male; full pelage, but genitalia immature	73	76	20	..	..
11. 6th May 1913, female; perforate, but juvenal pelage	74	73	22	16·5	14·5
12. 22nd Oct. 1913, male; testis 3 mm., adult pelage	75	68	20	14	12
13. 17th Sept. 1913, male; testis 11 mm., juvenal pelage below, adult above .	78	76	22	13	12
14. 21st May 1913, male; juvenal pelage above, adult white below	82	80	23	17	17
15. 22nd Oct. 1913, female; adult pelage, but imperforate	82	77	21	15	15
16. 25th Feb. 1913, female; imperforate, first pelage	83	90	22	15	17
17. 19th Feb. 1913, female; imperforate, first pelage	86	83	22	15	16

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.		Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
Sexually Mature Males:—						**Sexually Mature Females**:—					
1. 26th Aug. 1911	91	89	22	15·5	22·5	1. 25th Aug. 1911	87	78	23	15·5	21
2. 1st Sept. .	90	90	22	16	24	2. 29th ,, .	90	90	20	15	21
3. 7th ,, .	89	92	22	15	19	3. 20th Sept. .	88	80	21	16·5	19[1]
4. 9th ,, .	87	93	22·5	16	18	4. 21st ,, .	93	88	22	16·5	24[2]
5. 9th ,, .	84	94	23	16	18	5. 22nd ,, .	94	88	21·5	17	21[3]
6. 9th ,, .	83	89	22	15	14	6. 26th ,, .	85	91	22	16	21
7. 20th ,, .	81	76	21·5	15	15	7. 27th ,, .	85	85	21	16	18[4]
8. 20th ,, .	83	88	22	15	15	8. 27th ,, .	90	87	22	15	27[5]
9. 20th ,, .	89	100	22	16	25	9. 28th ,, .	88	84	21	15	18·5[6]
10. 21st ,, .	83	90	23·5	16·5	17	10. 4th October .	90	87	22	16	19
11. 22nd ,, .	88	98	22·5	16·5	22·5	11. 10th ,, .	85	82	21	15	22[7]
12. 23rd ,, .	84	83	22	15	17	12. 23rd ,, .	85	82	22	15	22
13. 24th ,, .	89	91	22	15·5	19	13. 25th ,, .	87	82	21	14	18[8]
14. 28th ,, .	90	97	23	16·5	22	14. 27th ,, .	88	84	21	15	17[9]
15. 28th ,, .	87	94	23·5	15·5	20	15. 6th November	91	93	22	17	22[10]
16. 28th ,, .	86	91	21	14	16	16. 6th ,, .	88	88	22	16	21[11]
17. 1st October .	88	94	23	15	23	17. 8th ,, .	83	83	22	15	17
18. 4th ,, .	92	89	22	16	23	18. 1st May 1912	85	85	21	15	29[12]
19. 23rd ,, .	90	90	22	15	22	19. 18th ,, .	89	90	22	16	23[13]
20. 25th ,, .	88	82	21	15	20	20. 23rd ,, .	83	81	22	16	17[14]
Average . .	87·6	87	22·2	15·5	19·6	Average . .	87·7	85·4	21·6	15·6	20·9

[1] 4 minute embryos. [2] 3 minute embryos. [3] 5 minute embryos. [4] 3 embryos. [5] 2 embryos.
[6] 7 embryos. [7] 5 embryos. [8] 4 embryos. [9] 2 embryos. [10] Suckling.
[11] 4 small embryos. [12] Suckling; stomach and intestines crammed with food.
[13] Suckling. [14] Impregnated; embryos indistinguishable.

A. SYLVATICUS BUTEI, BUTE, COLLECTED BY R. W. SHEPPARD.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).		Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).
Males:—					**Females**:—				
9th March 1912 .	95	78	21	15·7	12th March 1912 .	80	78	23	14·5
12th ,, .	90	80	22·7	15·5	13th ,, .	88	75	22	14·7
13th ,, .	90	80	23	15	14th ,, .	90	75	22·7	13·5
16th ,, .	90	75	22·5	15	16th ,, .	85	73	21	16
17th ,, .	90	77	21·7	15	20th ,, .	90	90	22	15
20th ,, .	100	86	22·5	15	20th ,, .	83	67	20·5	14·5
20th ,, .	87	76	22	14	21st ,, .	80	80	21	14·5
21st ,, .	95	85	22·5	15	22nd ,, .	80	73	22·3	16
23rd ,, .	95	75	22	12·5					
Average of 9 .	91·3	79·1	22·2	14·7	Average of 8 .	84·5	76·4	21·8	14·8

Remarks:—The average measurements for adult *sylvaticus* given in the above table are rather small. This seems to be due in part to the fact that the specimens were taken chiefly in the late summer or autumn, when many adolescent mice are to be found; mice collected in March or April would probably have given a greater average size for each sex. Six males, collected in East Aberdeenshire by C. S. Burnett between 11th and 17th April 1914, with skulls of the "Highland" type, averaged 94—92·2—21·6—16·1, the largest being 99—105—22—16. Aged English individuals probably attain a slightly greater size, although, no doubt, specimens in which the head and body exceeds 100 mm. are rare. The two largest (both males) caught at Reigate by Adams had the head and body 98, the tail 88 and 86 mm.[1] Two (male and female) of a series taken at Lowestoft, Suffolk, by Oldfield Thomas were measured as 100—94 and 93—22·5 and 21·2. Two males collected near Bridgend, Glamorganshire, measured 103—85—23, and 106—83—23. A male from Cashel, Tipperary, was measured by De Winton as 103—70 (damaged)—22·5—16.

Distinguishing characters:—Apart from the contrast between reddish upperside and white belly, the large foot is the most infallible point of distinction between any form of *Apodemus* and other British mice of somewhat similar size; the peculiarities of the skull and teeth, when available for examination, will always prevent any confusion with other genera. Immature Field Mice in the grey juvenal pelage may easily be confused with House Mice, especially when both are caught together out of doors; the slender feet and bicoloured tail afford perhaps the best outward means of distinguishing the young Field Mouse. The adult *A. sylvaticus* is distinguished from *A. flavicollis wintoni*, the only form with which it is likely to be confused on the British mainland, by its smaller size, duller coloration, and usually by the small size or absence of the pectoral spot.

(2) *A. sylvaticus butei* (Hinton).

1914. A. SYLVATICUS BUTEI, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 123; described from Mountstuart, Bute, Scotland; type an old male, No. 15.5.29.33 of the British Museum collection.

1913. A. SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835.

Distribution:—The island of Bute.

Description:—Size nearly as in *A. s. sylvaticus*, but with relatively much shorter tail and slightly shorter ears. General colour darker, the back and rump being rather heavily clouded with black; a faint trace of the pectoral spot is frequently present.

The **skull** is small, having in adults an average condylo-basal length of 22 mm. instead of 23 mm., as in true *sylvaticus;* its relative dimensions show, when compared with those of English skulls of the latter sub-

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[1] In 95 males measured by Adams the head and body averages about 90 mm., in 59 females 89·2 mm.; he found plenty up to 97 or 98 mm.

CRANIAL DIMENSIONS OF *APODEMUS SYLVATICUS* AND *A. FLAVICOLLIS*:—

	APODEMUS SYLVATICUS.							*A. FLAVICOLLIS WINTONI.*
	sylvaticus, England.	Wales.	Ireland.	Scotland.		Skye.	*butei,* Bute.	Hereford and Shropshire.
				1. Lowlands.	2. Highlands.			
Number of Skulls measured :—	12	4	6	3	11	8	11	3
1. Condylo-basal length Do. average	22·0 to 23·6 **23·0**	22·2 to 23·6 **22·97**	22·5 to 23·7 **23·08**	23·2 to 23·5 **23·33**	22·0 to 23·4 **22·6**	21·1 to 23·3 **22·46**	20·4 to 23·2 **21·94**	25·9 to 26·2 **26·06**
2. Occipito-nasal length	24·5 to 26·1	24·7 to 25·8	24·5 to 25·9	25·2 to 25·5	24·2 to 26·1	23·6 to 25·5	22·7 to 26·2	28·3 to 28·5
3. Zygomatic breadth	12·0 ,, 13·4	12·5 ,, 12·7	12·4 ,, 13·0	12·1 ,, 12·6	11·9 ,, 12·7	11·9 ,, 13·1	11·2 ,, 13	14·3 ,, 14·6
4. Inter-orbital breadth	3·8 ,, 4·4	3·9 ,, 4·2	4·0 ,, 4·2	3·8 ,, 3·9	3·8 ,, 4·2	3·8 ,, 4·2	3·8 ,, 4·3	4·3 ,, 4·5
5. Cranial breadth	11·1 ,, 12·2	11·2 ,, 11·7	11·1 ,, 11·8	11·0 ,, 11·3	11·1 ,, 12·0	10·7 ,, 11·6	10·5 ,, 11·8	12·2 ,, 13
6. Cranial depth (middle)	7·2 ,, 8·3	7·9 ,, 8·2	7·5 ,, 8·0	7·4 ,, 7·8	7·5 ,, 8·5	7·7 ,, 8·5	7·3 ,, 8·1	8·5 ,, 8·7
7. Condyle to m^3	10·3 ,, 11·1	10·4 ,, 11·1	10·5 ,, 11·0	10·7 ,, 11·0	10·0 ,, 11·0	9·6 ,, 11·1	9·4 ,, 10·8	12·4 ,, 12·5
8. Condyle to front of bulla	5·9 ,, 6·7	5·9 ,, 6·3	6·1 ,, 6·4	6·2 ,, 6·4	6·0 ,, 6·6	5·4 ,, 6·3	5·7 ,, 6·4	7·3 ,, 7·8
9. Nasal length	8·8 ,, 9·7	9·0 ,, 9·4	8·8 ,, 9·7	9·2 (2)	8·5 ,, 9·4	8·5 ,, 9·5	8·1 ,, 10·2	9·9 ,, 10·6
10. Nasal width	2·6 ,, 3 0	2·6 ,, 2·7	2·6 ,, 2·8	2·5 ,, 2·6	2·6 ,, 2·9	2·5 ,, 2·6	2·3 ,, 2·8	3·0 ,, 3·3
11. Palatal length	11·8 ,, 12·8	12·0 ,, 12·9	12·0 ,, 12·9	12·5 ,, 12·7	12·0 ,, 12·8	11·4 ,, 12·7	11·1 ,, 12·6	13·7 ,, 14
12. Diastema	6·3 ,, 6·9	6·1 ,, 6·9	6·2 ,, 6·7	6·5 ,, 6·8	6·2 ,, 6·8	6·0 ,, 6·6	5·9 ,, 6·6	7·3 ,, 7·4
13. Incisive foramina (length)	5·0 ,, 5·6	5·1 ,, 5 6	5·1 ,, 5·6	5·5 ,, 5·8	5·0 ,, 5·8	4·8 ,, 5·6	4·8 ,, 5·5	5·0 ,, 5·5
14. Incisive foramina (width)	1·5 ,, 1·8	1·7 ,, 1·9	1·5 ,, 1·8	1·5 ,, 1·7	1·5 ,, 1·9	1·5 ,, 2	1·5 ,, 1·9	1·8 ,, 1·9
15. Rostral breadth	4·2 ,, 5·0	4·3 ,, 4·8	4·2 ,, 4·8	4·3 ,, 4·6	4·3 ,, 4·8	4·2 ,, 4·4	4·0 ,, 4·5	5·3 ,, 5·5
16. Masseteric plate, least width	2·1 ,, 2·6	2·2 ,, 2·6	2·3 ,, 2·8	2·2 ,, 2·5	2·1 ,, 2·5	2·1 ,, 2·4	2·1 ,, 2·5	2·6 ,, 2·8
17. Maxillary cheek-teeth	3·3 ,, 3·9	3·4 ,, 3·7	3·5 ,, 3·8	3·5 ,, 3·8	3·3 ,, 3·7	3·5 ,, 3·8	3·3 ,, 3·7	3·7 ,, 4
Mandible length	13·8 ,, 14·6	13·7 ,, 14·4	13·8 ,, 15·3	14·1 ,, 14·5	14·0 ,, 14·7	13·2 ,, 14·5	12·9 ,, 14·2	15·9 ,, 16·4
Mandibular cheek-teeth	3·4 ,, 3·8	3·4 ,, 3·6	3·5 ,, 3·7	3·5 ,, 3·7	3·4 ,, 3·7	3·5 ,, 3·8	3·3 ,, 3·7	3·8 ,, 3·9

Reductions: 1. = 100 . . .	100	100	100	100	100	100	100	100
2. = . . . Average . .	108 to 111·5 **110·08**	108 to 112 **109·5**	106·5 to 111 **108·66**	107 to 110 **108·5**	108 to 112 **110**	109·5 to 112 **110·08**	109 to 113 **110·85**	109 (3) **109**
3. = . . . Average . .	52·2 to 57·7 **55·75**	53·5 to 56·3 **54·82**	54·3 to 56·8 **55·13**	52·1 to 54 **52·8**	52·2 to 57·2 **54·59**	55·2 to 57·5 **56·32**	54·9 to 57·7 **56·32**	54·8 to 55·7 **55·23**
4. = . . . Average . .	16·6 to 18·8 **17·73**	16·5 to 18 **17·5**	16·9 to 18·7 **17·57**	16·3 to 16·8 **16·56**	16·8 to 18·9 **17·6**	16·7 to 19·2 **18·03**	17·2 to 19·6 **18·44**	16·5 to 17·2 **16·9**
5. = . . . Average . .	48·4 to 51·7 **49·68**	47·5 to 50·4 **49·25**	47·8 to 50·7 **49·35**	47·2 to 48·1 **47·7**	49·1 to 54 **50 63**	49·7 to 52·5 **50·65**	49·1 to 53·7 **51·9**	46·7 to 49·6 **47·93**
6. = . . . Average . .	31·7 to 35·5 **34·02**	34·3 to 37 **35·17**	31·7 to 34·3 **33·36**	31·8 to 33·6 **32·56**	34·1 to 37·8 **35·56**	33·9 to 37 **36·01**	33·8 to 37·5 **35·76**	32·8 to 33·3 **33·1**
7. = . . . Average . .	46·2 to 47·8 **47·25**	46·4 to 47·1 **46·77**	46·0 to 47·4 **46·86**	45·9 to 46·8 **46·26**	45·5 to 47·4 **46·43**	45·5 to 47·8 **46·56**	45·8 to 47·7 **46·56**	47·6 to 47·9 **47·76**
8. = . . . Average . .	26·3 to 29·4 **27·45**	25·9 to 27·6 **26·77**	26·6 to 27·6 **26·93**	26·6 to 27·2 **26·96**	27·2 to 28·2 **27·61**	25·6 to 28·3 **27·02**	26·7 to 28·5 **27·7**	28·2 to 29·9 **28·76**
9. = . . . Average . .	38·0 to 42·3 **39·89**	39·8 to 40·6 **40·15**	39·1 to 41·6 **40·06**	39·1 to 39·6 **39·35**	37·9 to 41·8 **40·1**	38·7 to 40·9 **39·62**	38·0 to 44 **40·72**	37·9 to 40·9 **39·63**
10. = . . . Average . .	11·2 to 12·7 **11·89**	11·1 to 11·8 **11·52**	11·2 to 12·4 **11·92**	10·7 to 11 **10·83**	11·2 to 13·2 **12·18**	10·7 to 11·9 **11·35**	10·7 to 12·8 **12·03**	11·6 to 12·65 **12·01**
11. = . . . Average . .	53·1 to 55·2 **53·94**	53·2 to 54·7 **53·82**	53·1 to 54·4 **53·62**	53·9 to 54·5 **54·13**	52·5 to 56·2 **54·46**	51·8 to 55·2 **53·7**	53·5 to 55 **54·3**	52·5 to 53·6 **53·13**
12. = . . . Average . .	27·5 to 29·8 **28·51**	27·5 to 29·2 **28·05**	27·6 to 28·8 **28·3**	28·0 to 28·9 **28·53**	27·6 to 29·6 **28·9**	27·4 to 28·9 **28·11**	27·4 to 29·3 **28·35**	27·8 to 28·4 **28·13**
13. = . . . Average . .	21·9 to 24·4 **23·25**	22·1 to 24 **23·07**	22·7 to 24·4 **23·55**	23·6 to 25 **24·13**	22·3 to 25·2 **23·72**	22·7 to 25·2 **24·05**	23·3 to 24·6 **23·8**	19·8 to 21 **20·2**
14. = . . . Average . .	6·6 to 7·9 **7·34**	7·2 to 8·15 **77·2**	6·45 to 8 **7**	6·4 to 7·3 **6·86**	6·85 to 8·35 **7·78**	7·1 to 8·6 **7·78**	6·8 to 8·85 **8·04**	6·85 to 7·3 **7·03**
15. = . . . Average . .	18·3 to 21·4 **20·28**	19·1 to 21 **19·8**	18·0 to 20·9 **19·65**	18·5 to 19·7 **19·13**	19·4 to 21·6 **20·26**	18·4 to 19·9 **19·11**	18·2 to 20·8 **19·43**	20·2 to 21·1 **20·7**
16. = . . . Average . .	9·0 to 11·4 **10·25**	9·9 to 11·4 **10·75**	9·9 to 11·8 **10·74**	9·35 to 10·8 **10**	9·55 to 11·3 **10·31**	9·6 to 10·9 **10·07**	9·65 to 11·2 **10·52**	9·9 to 10·7 **10·33**
17. = . . . Average . .	14·85 to 17 **15·64**	14·6 to 16·2 **15·57**	15·1 to 16·5 **15·83**	15·0 to 16·2 **15·56**	15·0 to 16·7 **15·77**	15·7 to 17·6 **16·33**	15·1 to 17·2 **16·25**	14·3 to 15·3 **14·95**

species, distinctly greater zygomatic, inter-orbital, and cranial breadths, a deeper brain-case, shorter post-molar region (the bullæ being, however, enlarged rather than diminished), longer and rather wider nasals, greater palatal length, slightly longer and much wider incisive foramina, narrower rostrum, and longer molars.

For external and cranial dimensions, see tables at pp. 516 and 518 respectively.

Status:—*A. s. butei* is quite clearly differentiated from the English *A. s. sylvaticus*, and may be regarded as an insular development of either the same stock, or else of an older stock of mice of the *sylvaticus* type. Its exact significance cannot be appreciated until the relationship of the Highland Field Mice to those of England and the lowlands has been determined. The Field Mice of Skye and the Highlands approach *A. s. butei* more or less closely in some respects, and thus appear to occupy an intermediate position between it and the English *sylvaticus*. Among other Hebridean Field Mice the Bute form is readily distinguishable by its small size, dark coloration, and skull characters.

The habits of the Field Mouse are not far removed from being typical of those of mice generally. It is a hardy, active, non-hibernating animal of primarily vegetarian, but, when necessity arises, omnivorous diet, a fine jumper, a good climber, a capable digger, and a fair swimmer. It may, therefore, be found in any situation frequented by mice, as it is not tied down to the habitats of those which have become specialised in any particular direction. Thus it cannot compete with the House Mouse in the dwellings of mankind, and does not usually accompany it or the Harvest Mouse to the stackyards. Its activity and preference for a diet of berries and grain rather than of grass, raises it above the monotony of a Grass Mouse's existence, and keeps it in woods and the hedgerows of cultivated lands; it sometimes swarms in cornfields towards harvest-time. But it is found also in more open and barren districts, and is often numerous and well grown on desolate islands or rough mountains. In Clare Island, Co. Mayo, Ireland, it inhabits the walls of loose stones right up to the summits of the hills, and in the opposite direction, it may be found on the sea beach,[1] generally in the marram-grass,[2] the seeds of which and of other plants it probably eats, with the addition of the varied dainties cast up by the waves. Its adaptability is so wide that it thrives equally well in the flower-beds of Regent's Park, London, and on the lonely hills of Sutherland.[1] As an instance of its powers of surviving in unusual situations—Mr J. E. Harting once caught one which landed at Dobbin Island, Pagham Harbour, Sussex,[2] Mr G. T. Rope has observed one swim out leisurely into the centre of a pond,[3] a correspondent of Mr H. E. Forrest (*N. Wales*, 1907, 50) watched one swim a considerable distance across flood water at Llanderfel, and Mr Millais (p. 195), suggests that it is capable of swimming 200 yards without fatigue. It is, of course, a much wider wanderer than any of the "Voles," and predominantly, if not entirely nocturnal,[4] which is no doubt a cause of its prominent round eyes, recalling those of the Dormouse. Yet, like the Common Shrew and Bank Mouse, it may be trapped by daylight, so that it is unsafe to lay down an absolute rule of conduct for it. Individuals of nocturnal animals found out by day are usually either feeble, sick, or senile.

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[1] G. T. Rope, *Zoologist*, 1874, 3865.

[2] G. T. Rope (*Zoologist*, 1887, 206) thus encountered it between Dunwich and Sizewell, Suffolk, on a beach cut off from cultivated land by wide marshes.

Where it abounds, it may be found at night, if searched for with a lantern, bounding along in a peculiar zigzag and erratic manner,[5] remotely resembling the movements of a kangaroo or gerboa, and at all times, even when it walks, its long hind feet give it a characteristic "action" in moving about, which is probably its most peculiar feature; and Mr Douglas English has known one to leap down 15 feet, and proceed unhurt, thus showing the elasticity of its limbs. The tracks of the Field Mouse (Fig. 85) are characterised by the length of the median tail mark; Adams has observed them in snow extending for a distance of 100 yards—clear proof that these mice roam comparatively far from their homes. It sits bolt upright, using the tail for support.

Its large ears appear capable of detecting the slightest sound; they twitch convulsively at a chirp or whistle so faint as to be barely audible to human ears.[1] The sense of smell is probably acute also, and perhaps the principal guide in the search for food.

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[1] Millais (189).

[2] Specimen in British Museum of Natural History; see also Harting, *Zoologist*, 1891, 185.

[3] *Zoologist*, 1891, 185.

[4] Lataste; Rope, *Zoologist*, 1887, 201.

[5] Rope, *Zoologist*, 1887, 206. I made similar observations respecting the nocturnal *Muridæ* in South Africa (Barrett-Hamilton).

In disposition it is gentle and inoffensive, slow to retaliate, so that it rarely bites unless roughly handled. Extremely timid, it cannot, perhaps on account of poor sight, be called shy, for it may sometimes be observed from a close distance, or caught with the hand,[2] and no animal is more easily trapped. The Field Mouse lacks the objectionable odour of the House Mouse, so that, like the Dormouse, it ought to prove a suitable pet; but, although extremely beautiful, it is not as intelligent as the House Mouse, and, while easily fed, frequently breeding, and sometimes exceptionally friendly, it does not always become so tame as to repay the trouble expended on it. Some, however, have found it very attractive, and the late Dr W. E. Leach[3] is said to have allowed several to run about freely on his breakfast table. It sometimes enters houses, perhaps by climbing the creepers, but this habit is more characteristic of the Yellow-necked Field Mouse.[4]

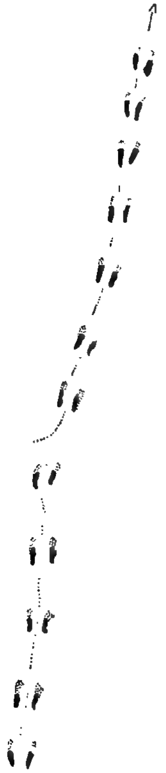

FIG. 85.—SPOOR OF FIELD MOUSE IN SNOW. (From a sketch by L. E. Adams.)
Hind feet (dark) on top of prints of fore feet (lighter).

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[1] G. T. Rope, *Zoologist*, 1887, 203.

[2] Eliza Brightwen, *More About Wild Nature*, 1892, 58; and L. E. Adams in Millais, 189.

[3] Bell, ed. ii., 294; see also, Eliza Brightwen, *op. cit.*, 120.

[4] See William Thompson, *Nat. Hist. Ireland*, iv., 15, for Ireland (Belfast); W. Evans for Scotland (Edinburgh district); G. Rope, *Zoologist*, 1887, 206 (visits dairies for milk); Millais, 189; Coward and Oldham; Jenyns, *Observations in Natural History*, 1846, 74.

It seems to be at least partially gregarious. Mr G. Bolam states that it appears to live in pairs, and the young associate with the parents until a considerable age (*Bradford Sci. Journ.*, Jan. 1912, 213). Dr Henry Laver finds that the work of storing provisions is shared by a company, and that fourteen or fifteen may sometimes be dug out of the burrow. Consequently in captivity a large number may be kept together, the males, females, and young sleeping together in perfect amity, and the latter being even fed indiscriminately[1] by the mothers,[2] as found by Mr R. M. Barrington. These observations indicate that the wild male is not dangerous to his family, but not necessarily that he resides with them. The fact that the dams would suckle the young of the colony promiscuously might result from the confusion[3] resulting from a mixed *ménage*, in which identification of any particular offspring would be impossible to keep up. The observations show, however, that the mice are extremely sociable and good tempered, friendly to strangers of their own species, and that their system is quite opposed to that of the exclusive Water Rat.

Its dietary is of the usual wide murine type, ranging from roots, bulbs, nuts, and berries to members of its own species,[4] but avoiding the grass-stalks beloved of Grass Mice. It is a great plague in cornfields and gardens, especially to early sown peas.

According to Mr Barrington's[5] observations these mice seldom feed on blades of grass, but more often on the roots; they eat clover and dandelion leaves, while the unexpanded dandelion flower seemed to be esteemed a great delicacy; also milk, oats, wheat, barley, chestnuts, beech nuts, walnuts, arbutus berries, gooseberries, apples, grapes, and every variety of fruit; almonds were not much liked; the captives liked to tear a lot of grass to pieces. Mr Adams describes his captives as peeling but not eating horse-chestnuts, refusing apples and not touching almonds or grass; crocus bulbs were eaten readily, but acorns were, with the exception of carrion (their fellows, Bank Mice and Shrews), the favourite food; "my captives did not care for haws, though they preferred them to hips; this was doubtless because they had the choice of so many dainties." Lataste's captives fed on grains, bread, salad, carrots (little), potatoes (little), nuts and almonds especially; sloes appear in the list given by Oldham and Coward[1]; when wild,[2] they eat the seeds of butcher's broom and are fond of carrots. Bell (*ipse*, ed. ii., 294) mentions stores of acorns, nuts, corn, various seeds and roots; Mr Steele Elliott,[3] in addition to some of these, found haws, holly berries, and fungi, e.g., *Boletus badius* and *Paxillus involutus*, in winter stores; cherry stones in store were found by Mr St John[4]; hips and blackberry seeds are mentioned by Mr C. Oldham,[5] slow-worms by Mr W. H. P. Saunders,[6] eggs by Mr E. T. Danberry[7]; strawberries in heaps were observed by Barrett-Hamilton—"the habit of heaping its food being halfway towards storing." It has been known, "in common with others of the family, to eat considerable quantities of putty without apparently suffering any ill effects.[8]" A very extensive literature relating to their destructiveness may be found in the periodicals devoted to gardening. About 300 were trapped in a fortnight at a crocus bed by Heatley Noble (Millais, 190). These mice attack lily and hyacinth bulbs as well; on the other hand, their attacks on the latter are said to have indicated to Dutch growers a method of increasing the bulbs by splitting (Millais, 190). Service states[9] it to be very destructive to indoor fruit, as peaches, nectarines, tomatoes (ripe seeds).

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[1] Observations of this sort made on captive animals under artificial conditions must be applied with great care to wild individuals.

[2] *Zoologist*, 1882, 121-3.

[3] Cows are quite sociable and gregarious animals, and, if allowed to rear their calves, are attached only to their own young. But if a number of cows and calves be confined in a yard for a very few hours they soon lose the power of distinguishing their own young, and promiscuous suckling results.

[4] In eating a mouse it begins with the brain, and then eats a large hole in the back, whereas shrews begin at the upper ribs, and then eat their way to the brain (L. E. Adams, *MS.*).

[5] *Loc. cit.*

Colonel Davies Cooke (in Forrest, North Wales, 50) describes it as entering and robbing beehives at Mold, and William Thompson (iv., 15) mentions two nests found in a beehive at Fort William, near Belfast, the mice having entered by the same aperture as the bees; numbers of the mice were caught

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[1] *Op. cit.*

[2] G. Rope, *op. cit.*, 204; and Millais.

[3] *Journ. Birm. Nat. Sci. and Phil. Soc.*, 1896-9.

[4] *Nat. Hist. and Sport in Moray*, 234.

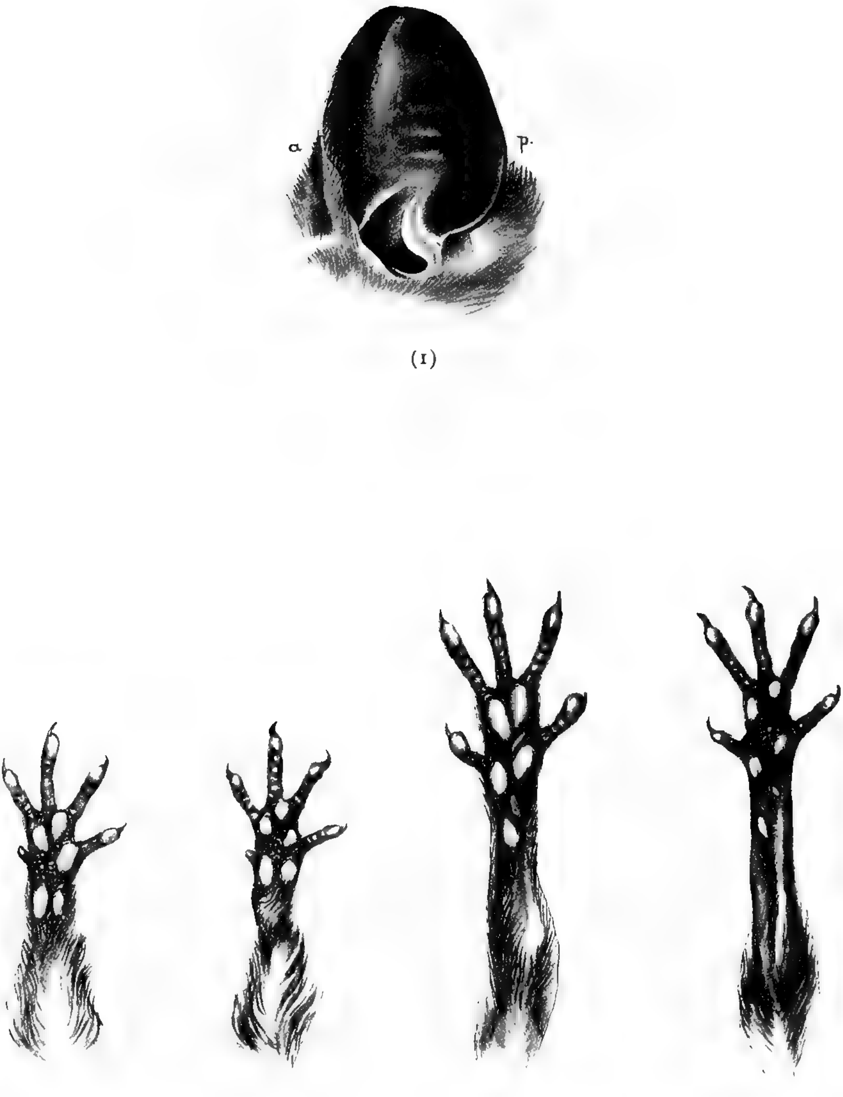
[5] *Zoologist*, 1900, 421.

[6] *Field*, 27th April and 4th May 1907.

[7] *Nature Notes*, 1899 (1900, Z. 157).

[8] Aflalo, 75.

[9] *Ann. Scott. Nat. Hist.*, 1896, 205.



(1)

(2) (2*a*) (3) (3*a*)

THE FIELD MOUSE (*Apodemus sylvaticus*).

(1) LEFT EAR; (2 and 2*a*) LEFT HAND; (3 and 3*a*) LEFT FOOT.
(Three times life size.)

in traps placed around the hives; and in winter the mice often broke into the hive and ate the honeycomb.[1] The connection between mice, humble bees, and clover as commented upon by Charles Darwin, is noted above under Grass Mouse at p. 452.

When climbing the hedgerows, which it does to the very tips of the branches, in search of berries, it frequently uses a bird's nest[2] as a dining platform, as perhaps first described by Mary Howitt,[3] in 1834, by Mr Charles Oldham,[4] in 1899, and by H. E. Forrest[5] in 1907. Sometimes what was meant for a temporary occupation becomes permanent, for Mr Millais (p. 192) found a deserted Blackbird's nest roofed over with moss; Mr Harting[6] found another case in which a Missel-thrush's nest, twelve feet up an oak, was roofed with grass and leaves; and a third instance was met with in the foundation of a Rook's nest in an elm of considerable elevation (Millais, 193). It is probable that on expeditions like this it sometimes yields to the temptation to devour young birds or eggs, whence these are included in its dietary by J. H. Blasius and Victor Fatio; Mr G. G. Cummings, however, accuses it of frequently sucking eggs, especially those of finches, and Mr G. H. Caton Haigh has known it to eat the heads off a nestful of young thrushes.[7] Mr Oldham found that the mice do not usually eat the soft parts of berries, but extract the seeds, as in the case of hips, through a hole nibbled in the side; they then chisel off one end of a seed and extract the kernel. The empty seed-case and the pulp are dropped on the nest until they may form a heap representing the contents of a quart measure.[8] It seems that the convenience of a bird's nest is so much appreciated that acorns are carried up to them from the ground.

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[1] On the other hand, Barry (ed. ii., 1808) states that in Orkney the Field Mice are sometimes deprived of their burrows by the field bees.

[2] Those of Thrush, Blackbird, Hedge-sparrow, Greenfinch (7 feet from the ground), or even the fragile nest of the Whitethroat have been noted (Oldham). C. E. Wright has also seen this (MS. per L. E. Adams). The Bank Mouse makes a similar use of deserted nests (see p. 414 above).

[3] "In the Hedge-sparrow's nest he sits,
When its summer brood is fled,
And picks the berries from the bough
Of the hawthorn overhead."

Quoted by T. A. Coward, *Zoologist*, 1901, 221, from *Sketches of Natural History*, 1834, a volume of poems for children.

[4] *Zoologist*, 1899, 27.

[5] *Op. cit.*, 50.

[6] *Vermin of the Farm*, 1892, 14.

[7] In Mr H. E. Forrest's *North Wales*, 50. L. C. Creaghe-Haward (*Field*, 20th March, 1909, 510) suggests that a Field Mouse killed a Hedge-sparrow, but the evidence is not absolutely conclusive.

[8] Mr Adams has made very similar observations.

According to Blasius, it will bark young trees when in want, a circumstance noted also by Mr Rope[1] and Mr Abbey.

A remarkable winter habit of entering disused tunnels at Alderley Edge, Cheshire, to more than 150 yards from the entrance, was related by Mr Oldham,[2] the object, as shown by the contents of their stomachs, having been to feed on hibernating gnats, flies, and moths. The burrows in the tunnels themselves and the food seemed to indicate that they actually lived in the recesses for the time being, and became entirely insectivorous, and were not merely on a visit. In a case recorded by Mr Edwin Birchall[3] the wings of hundreds of individuals of twenty species of moths were found in a small cave by the river Wharfe, near Ilkley, Yorkshire; the circumstances pointed to the work of Field Mice, and on a trap being set, one was caught, the mice having apparently carried their prey into the cave from the adjoining woods. S. Clogg, however, referred the killing of the moths to a spider whose web was observed in the cave (*Zoologist*, 1866, 105, 350, 458; 1869, 1719; 1871, 2763); while Edward Newman (*ibid.*, 1866, 386), Henry Doubleday (*ibid.*, 1866, 387), and W. F. Howlett (*Journ. cit.*, 1871, 2802) attributed it to bats.

Quite unlike the House and Harvest Mice, the Field Mouse is rarely found in stacks of corn, and enters dwelling-houses very exceptionally, wherein it appears to differ from the Yellow-necked Mouse, which seems quite fond of houses.[4] An exceptional instance was sent us by Mr C. H. Alston, in whose house, at Letterawe, Loch Awe, Argyll, House Mice are fortunately unknown. Their place is taken by Field Mice, which seem to be now permanently in occupation. Unlike the House Mouse, they rarely gnaw a hole for themselves, but enter the house by burrowing through crevices in the stones in the foundations, and then creep up through small cracks in the floors, and thus get inside the partitions.

Its destructiveness is increased by its provident habit of amassing[1] stores of provisions in a separate chamber of its burrow near its dwelling apartment or altogether apart, in which work it is very diligent. Mr R. M. Barrington[2] has observed that captives covered up single grains of wheat with the nose, like a dog, sometimes using the hind legs to scrape together a heap of material over it. Unlike dogs, they hid many things in the same place.

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[1] *Op. cit.*, 204.

[2] *Zoologist*, 1900, 421.

[3] *Ibid.*, 1866, 8, 284.

[4] Mr Adams informs us that he has caught these mice frequently in cellars and outhouses; on one occasion he found some in a stack.

It certainly does not hibernate, for it may be trapped freely at the coldest part of the year. Charles St John[3] thought that on the approach of cold winds or rain they shut themselves up in their underground habitations, closing the apertures carefully, but corroborative evidence of this habit is desirable.

The Field Mouse is extremely prolific, and the female produces several litters in a long polyœstrous sexual season, which probably lasts the greater part of the year.

Mr Barrington[4] found that young captured on 1st October first made a nest of grass when about thirty-six days old. Of two females which, with a single male, survived to reach maturity, the produce was as follows, young being first born when the dams were about five and a half months old :—

Female A.—	7th or 8th March,	3 young,	...	days' interval
	31st March,	3 „	24	„
	24th April,	3 „	24	„
	17th May,	4 „	23	„
	12th June,	4 „	26	„
	9th July,	4 „	27	„

(In the case of the last two litters identification was not absolutely certain, one female having escaped.)

Female B.—	19th March,	5 young,	...	days' interval
	18th April,	5 „	29	„
	11th May,	5 „	23	„

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[1] A well-known habit :—

"Saepe exiguus mus
Sub terris posuitque domos atque horrea fecit."

Vergil, *Georg.*, i., 181 ; but why the rooting of pigs has been by writer after writer, at least from Pennant (1768) to Johnston (1903), supposed to be "chiefly owing to their search after the concealed hoards of the Field Mice," is difficult to understand.

[2] *Op. cit.*, 123.

[3] C. St John., *Nat. Hist. and Sport in Moray*, 1882, 234.

[4] *Op. cit.*

Until the young were three weeks old, the mother frequently carried them back to the nesting-box, usually lifting them by the side of the belly, midway between the fore and hind legs, the mother's erect head raising them completely above the ground. The dam soon discovered that her load must be changed at the narrow entrance to the nesting-box, and so dropping the young ones outside, she entered, and turning round dragged each baby in head foremost. Occasionally the parents attempted to drag older children into the nest.

Mr Barrington's remarks are confirmed by Dr Henry Laver,[1] who observed copulation, and found that the periods of gestation and œstrus seem to be respectively twenty-four to twenty-five and six days, copulation taking place a few hours after the birth of a litter, and six days after a previous ineffective pairing.

It must be noted that Mr Barrington's observations are in one or two respects abnormal. The original mice having been taken in the autumn, did not produce young until the following spring, when five and a half months old. Had they been the young of early spring litters, they might have been expected to breed when younger.

A female in the possession of Monsieur Fernand Lataste, being deprived of her young, imposed upon herself the task of rearing a strange baby, and Mr F. H. Parrott informed Mr Cocks that one he had reared a litter of Grass Mice.

As a result of his examination of thirty-four litters, Mr Adams thinks that the average number of young per litter is about five; he has seen one litter of nine young, three of seven, five of six, thirteen of five, nine of four, two of three, and one of two. Mr Adams has found young in every month of the year excepting January, and, very curiously, June and July.

The breeding habits probably resemble those of the House Mouse[2]; the young cling to the mother's teats just like other mice,[3] and it is extraordinary to what a pace she attains with a family of young, each probably a third of her own size, attached to her.

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[1] *Field*, 19th August 1905, 378; and *in lit.*

[2] Lataste.

[3] Gilbert White, Letter lii. to Daines Barrington, 26th March 1773; R. M. Barrington, *op. cit.*; J. J. Briggs, *Zoologist*, 1856, 5311 (? species doubtful); Victor Fatio witnessed a female ploughed out of the ground with the young attached to her hair and tail (p. 213). The famous incident which made Burns write of a "wee sleekit, cowrin', tim'rous beastie" may be recalled. See also Rope, *Zoologist*, 1873,

Some authorities, *e.g.* Bonhote, speak of a domed nursery built above the ground; and Mr Cocks has not infrequently found such during haymaking. In the autumn, according to Mr Adams, breeding-nests may be commonly found under roadside heaps of hedge-cuttings. Usually the nest is placed below ground in the characteristic burrow (Figs. 86, 87). The burrows are excavated in cornfields during the summer, and the mice often remain in them in the stubbles until the plough turns them out in the autumn.[1] Sometimes the burrows appear to be only of a temporary nature, a short steep tunnel, perhaps only two or three inches long, leading to a simple enlargement containing the usual murine globular nest of dried grass. The more permanent burrows may be 3 feet deep, and in them the mice commonly lay up stores of acorns, and stay through the winter (L. E. Adams).

Its voice in anger is described as somewhat high-pitched, but it makes other sounds of a quiet, chuckling nature.[2]

Although its annual fluctuations do not appear to be so violent as those of voles, it is said to have taken part in the mouse plagues which devastated the Forest of Dean in 1813-14 (see above at p. 451). As stated on p. 418 above, Mr Cocks observed great swarms of this species and of the Bank Mouse, at Poynetts, Buckinghamshire, in 1900. Macpherson mentions one which lived upwards of two years in captivity.

All predaceous creatures eat Field Mice when they have an opportunity, and in some localities they are the favourite food of owls, as shown by their pellets. Mr Aubyn Trevor-Battye was informed[3] that in the dry summer of 1893 the Black-headed Gulls[4] breeding on Scoulton Mere often brought "mice" to their young, but these were more likely to have been the diurnal Grass Mice than the nocturnal Field Mice.

3610. Adams once saw a female escape from the bolt-hole of her nest with three or four young hanging on; these dropped off as the dam leapt away, the last one at about 5 yards from the burrow.

[1] Adams once found "a breeding-nest underground on a Yorkshire moor, just like those in cornfields."

[2] Millais, 195.

[3] Lydekker, 187.

[4] *Larus ridibundus*, Linn.

No small mammal except the Common Shrew is more easily trapped. It will take any edible bait, vegetable or animal, and no concealment is needed for the trap.

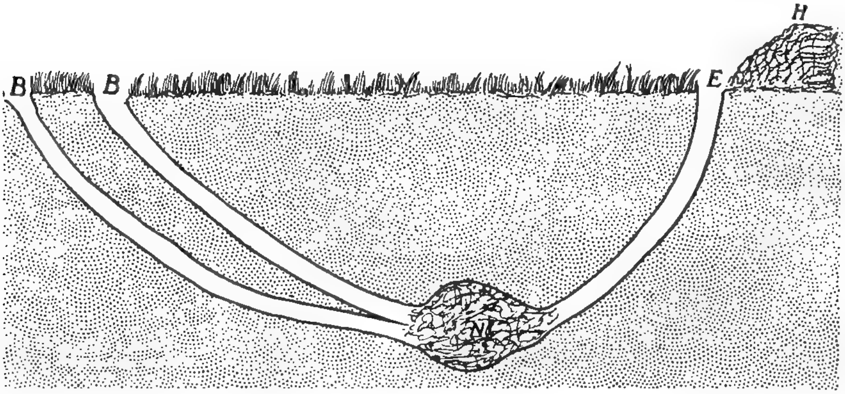


FIG. 86.—SECTION OF BURROW OF FIELD MOUSE (diagrammatic). *H*, heap of excavated earth, all at one entrance; *B*, *B*, bolt-holes; *N*, nest. (From a sketch by L. E. Adams.)

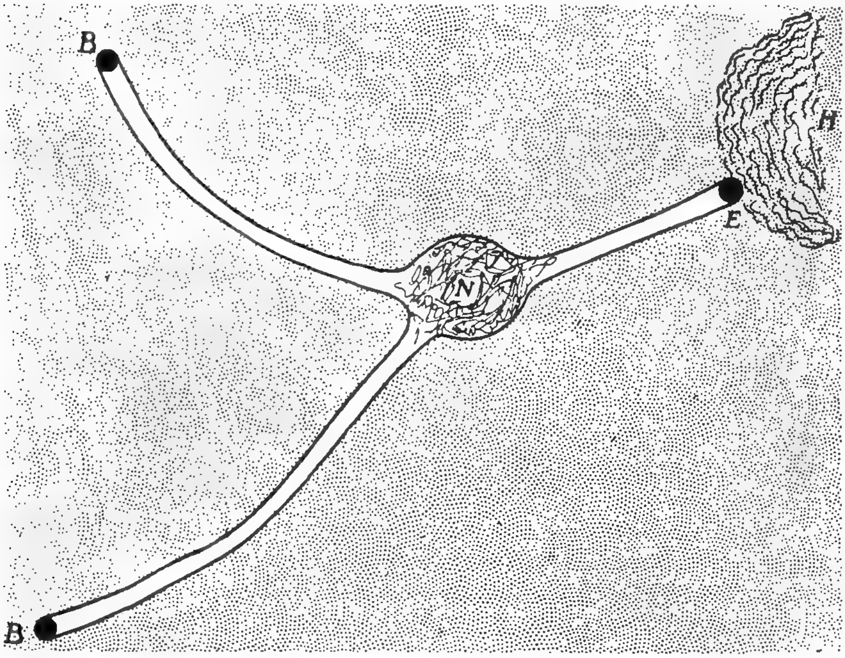


FIG. 87.—PLAN OF THE BURROW OF A FIELD MOUSE SHOWN IN SECTION IN FIG. 86. (From a sketch by L. E. Adams.)

THE HEBRIDEAN FIELD MOUSE.

APODEMUS HEBRIDENSIS, de Winton.

1895. MUS HEBRIDENSIS, W. E. de Winton, *Zoologist*, October 1895, 369-371; described from Uig, Island of Lewis, Outer Hebrides, type specimen, No. 95.10.25.1 of British Museum collection; (*Apodemus*) Miller, *Catalogue*, 1912, 824.

1895. MUS SYLVATICUS HEBRIDENSIS, W. E. de Winton, *Zoologist*, November 1895, 426 (designates type specimen); Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 403; Johnston, Millais, Trouessart.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835 (in part).

History:—De Winton seems to have been the first to record the presence of field mice in the Outer Hebrides, where he trapped a number of specimens in Lewis in the summer of 1894 (*Ann. Scott. Nat. Hist.*, 1895, 53). In the following October (*loc. cit. supra*) he published a description of his *Mus hebridensis*, based on these specimens and others taken by Pinney in Barra. Later in the year Steele Elliott claimed priority for the discovery, but it appears that his remarks refer to the St Kilda Field Mouse, a different form, as, indeed, was suggested by de Winton. In the first paper on the mammals from the Inner Hebrides (see footnote to p. 422 above) we referred the field mice of Great Cumbrae, Arran, Gigha, Islay, Jura, Mull, and Tiree to *A. sylvaticus*. As the result of a detailed investigation of the cranial characters the field mice of the islands named, together with those of Rum and Eigg, have now to be regarded as local races or sub-species of *hebridensis*. Four of these forms have received names and are described below; it is highly probable that with further material several of the other insular races will have to be given sub-specific rank.

Description:—Size usually larger than in typical *sylvaticus*, and of stouter build; the feet longer; the tail and ears relatively shorter. The **coloration** varies in the different sub-species; sometimes the backs are dark, as in *A. h. hebridensis*, *maclean*, and *fiolagan*, sometimes rufous, with few black hairs, as in *cumbræ;* the underparts sometimes have a large pectoral spot, and are more or less generally suffused with buff or yellow, as in *h. hebridensis;* or the pectoral spot may be quite small or absent, and the whole ventral surface nearly clear silver, as in *maclean;* the line of demarcation may be irregular or straight, clearly or faintly defined, the degree to which it is evident being dependent upon the colour of the flanks as well as upon that of the ventral surface.

The **cheek-teeth** agree in form with those of *sylvaticus*. The **skull** is usually (but not in *cumbræ*) larger than in *sylvaticus;* in *hamiltoni* it approaches that of *flavicollis* in size. In general appearance it is like that of *sylvaticus*, having the brain-case smoothly rounded; in *hamiltoni*, however, the fore part of the brain-case is angular and distinctly ridged. In all forms it is distinguished from *sylvaticus* by its shorter post-molar length and smaller bullæ, and usually by its greater palatal length, longer diastema, and tooth-row. These differences will be appreciated best from an examination of the tables on pp. 518 and 538.

The external and cranial dimensions are given in the tables at pp. 536-9. Further special characters are noted under the sub-species, which are as follows:—

(1) *A. hebridensis hebridensis*, de Winton.

For **Synonymy**, see under species.

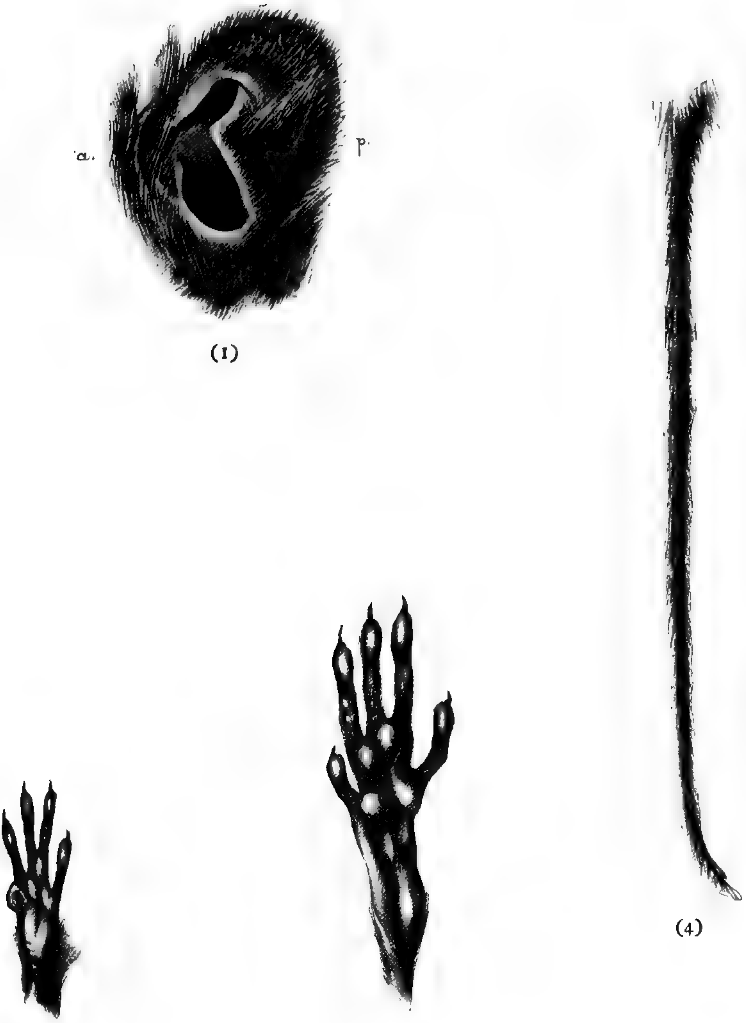
Distribution:—Lewis, Outer Hebrides.

Description:—The typical Hebridean Field Mouse differs from *A. s. sylvaticus* in its larger size, stouter build, longer feet, shorter ears, and dull under side. In general size it, when old, about equals *A. f. wintoni*, but its ears are smaller than those of the much smaller *sylvaticus*. A pectoral spot is present and usually rather longer than in *sylvaticus*, but not forming a collar. In **colour** the back and flanks are about as in *sylvaticus*. The typical adults from Uig, western Lewis, collected in September, have the under-parts heavily washed with buff, and show no distinct line of demarcation; the tail is uniformly brownish-grey, and is shorter and thicker relatively than in *sylvaticus*. Attention was called by de Winton (Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404) to the possible occurrence of **sexual differences** in the pelage of this form; he noticed that "young males appear to lose the dull hues of immaturity of the upper side, and to don the reddish colour of maturity at an earlier age than do the females, so that young males and females of the same age are actually distinguishable by their colour alone." In a series of seven adults collected by Mr Anderson between 5th and 10th April 1913, at Garrynahine, Callernish, western Lewis, the four females are like the Uig specimens, but the males have feeble pectoral spots and but slight trace of an abdominal yellowish wash, while the line of demarcation is rather sharply indicated. The females from Tarbet, Harris, are also like the Uig specimens in colour; as will be seen from the table at p. 536, both these and the mice from Callernish are smaller than the typical series, though the relative size of the feet and ears is the same.

The **skull** differs from that of *sylvaticus* in its larger size, narrower zygomatic, inter-orbital and cranial widths; the bullæ are smaller, the cheek-teeth and diastemata longer—characters which are expressed in the shorter post-molar and longer palatal regions.

Local variation:—Apart from the reduction of size noted above in

PLATE XXX.



THE HARVEST MOUSE (*Micromys minutus*).

(1) LEFT EAR; (2) LEFT HAND; (3) LEFT FOOT; (4) TAIL.
(Three times life size.)

the specimens from Callernish and Tarbet, Harris, there is in eastern Lewis a well-marked deviation from the typical form of Uig. Barrett-Hamilton (*Proc. Zool. Soc.*, London, 1900, 401) referred three small dark specimens from Eisken, eastern Lewis, to his *M. sylvaticus celticus*, and he mentions (*op. cit.*, 395, 403) that de Winton thought that this small form might be an accidental introduction, his *hebridensis* keeping to its own side of the island. The Eisken specimens may have been immature. A series of fourteen adults and two young specimens were collected at Stornoway by Mr D. Anderson in the latter part of March 1913. Apart from the uniform reduction of size which they show when compared with the typical series from Uig, there is little in external appearance to distinguish these specimens from true *hebridensis*. Some of the males are silvery below, like those from Callernish, but in others and in the females there is a more or less well-marked tendency for the lower parts to be suffused with buff. In a young male (head and body, 77) the coat is like that of the adult, having the flanks lighter than the back, the under-surface silvery, with a bright pectoral spot and a paler median wash of buff behind; in a young female (head and body, 78) the flanks are still dark, and though a faint trace of the buff stripe can be seen, the under-surface is greatly darkened by the bases of the hairs (*cf.* p. 532). In average size the skulls are slightly smaller than in typical *hebridensis* (condylo-basal length, 23·64 instead of 24·1 mm.); they are relatively broader and the post-molar length is very slightly increased, the palatal length still more slightly diminished; but in both the latter respects there is substantial agreement with *hebridensis* and considerable difference from any British form of *sylvaticus*. These specimens may eventually have to be separated from *h. hebridensis*, but the separation cannot be made until a much more extensive series of skulls from western Lewis than that at present available has been acquired.

In the few specimens available at present from **Barra** the backs are brighter than in *h. hebridensis*, there being fewer black hairs; the under-surface is silvery, with scarcely a trace of a pectoral spot or buffy suffusion; the line of demarcation is clearly defined. In the single adult skull the small size (condylo-basal length, 23·1) and greater breadths are nearer to the Stornoway series than to typical *hebridensis*; a marked feature is that the palatal length is shorter than in any other form of *hebridensis*, though, on the other hand, such short palates occur occasionally in individuals of the other races.

Two specimens from **South Uist** resemble those from Barra in the slight development of a ventral buffy suffusion; although old, the small size, in particular of the feet, is noteworthy.

Mention may be made here of two field mice taken on **Eigg**, 29th March 1913, by Mr P. D. Montague. Like the grass mouse of the island (p. 438), these mice have unusually long thick fur; the back is dark; there is a pectoral spot and median wash of buff below—features which are better developed in the male than in the female. The skulls show greater palatal length, a wider masseteric plate, and longer molars than in *h. hebridensis;* but since the teeth are only slightly worn these differences may be due to immaturity. The status of this animal cannot be determined without further material.

(2) *A. hebridensis hamiltoni*, Hinton.

1914. APODEMUS HEBRIDENSIS HAMILTONI, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 126; described from Rum, Inner Hebrides; type specimen, a male, No. 15.5.28.22 of the British Museum collection.

Distribution:—Confined to the island of Rum.

Description:—This field mouse agrees in general size and proportions with the largest specimens of *A. h. hebridensis*, but has a still larger and a more massive skull. **Colour**:—The backs are about as in *hebridensis;* the ventral surface is silvery, darkened by the hair-bases, with an evident though not very bright pectoral spot, and some slight trace of a yellowish wash; the line of demarcation is a little irregular, and moderately defined. The **skull** is distinguished from that of *h. hebridensis* by its greater size, general narrowness (the nasals, however, being as broad as in the Stornoway series), and greater palatal length. The shoulders of the brain-case are rather strongly ridged in a manner recalling the skull of *A. flavicollis wintoni*, from which, however, it is readily distinguished by its much smaller bullæ, greater palatal length, and longer incisive foramina.

For external and cranial dimensions, see tables at pp. 537 and 538 respectively.

(3) *A. hebridensis cumbræ*, Hinton.

1914. APODEMUS HEBRIDENSIS CUMBRÆ, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 128; described from Great Cumbrae, Inner Hebrides; type specimen, a female, No. 15.5.29.26 of British Museum collection.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835 (in part).

Distribution:—The island of Great Cumbrae, Inner Hebrides.

Description:—This mouse is smaller than typical *hebridensis*, in size about as *s. sylvaticus;* the tail and ears are relatively longer, the feet relatively as large as in *h. hebridensis*. **Colour** of back rufous, with very few black hairs; the belly is silver, with hardly a trace of the pectoral spot; the line of demarcation is clear, but owing to the light colour of the flanks, the contrast is not very striking. The **skull** is scarcely larger than in *s. sylvaticus*, but it agrees in all essential respects with that of *hebridensis;* it differs from *h. hebridensis* in having the inter-orbital region narrower, the brain-case broader and deeper, and the nasals, diastemata, and incisive foramina a little shorter.

Related forms:—Similarly rufous, but larger forms are known from the islands of Gigha and Tiree (*Proc. Zool. Soc.*, London, 1913, 836, where they were referred to *A. s. sylvaticus*). The only specimen from **Gigha**, an old nursing female, has the back and flanks slightly darker and a much more clearly defined line of demarcation; the tail is relatively shorter. The specimens from **Tiree** are externally much larger, with considerably shorter tails and ears than in *cumbræ*, which, however, they strongly resemble in colour and the small size of the skull; in the latter the palatal length is slightly increased.

(4) *A. hebridensis maclean*, Hinton.

1914. APODEMUS HEBRIDENSIS MACLEAN, Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 129; described from Mull, Inner Hebrides; type specimen, a male, No. 15.5.29.27 of British Museum collection.

1913. APODEMUS SYLVATICUS SYLVATICUS, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 836 (in part).

Distribution:—The island of Mull, Inner Hebrides.

Description:—Size, and proportions of feet, tail, and ears nearly as in *h. hebridensis;* **colour** much darker than in *cumbræ*, the back clouded by relatively numerous long black hairs; flanks rather light, becoming more pallid below; ventral surface nearly clear silver, with at the most only a feeble trace of the pectoral spot; the line of demarcation is somewhat irregular, and not at all sharply defined. The **skull** approaches that of *h. hebridensis* in size, differing in its exceptionally narrow zygomatic arches, slightly narrower inter-orbital region and brain-case, the latter a little more depressed, and smaller bullæ.

Closely related forms:—The field mice of **Jura** (referred *Proc. Zool. Soc.*, London, 1913, 836, to *A. s. sylvaticus*), judging from three specimens collected in May, have shorter tails and are still darker than those of Mull. In them the back is heavily clouded with black and the flanks are dark; the under-parts are clear silver with a very slight trace of the pectoral spot; the line of demarcation is straight and sharply defined. The skull has wider zygomatic arches, broader and deeper brain-case, longer pterygoid fossæ, shorter nasals and diastemata, and broader incisive foramina and masseteric plates; in some of these cranial features the Jura mice make a nearer approach to *h. hebridensis* than does *maclean*, although in coloration they depart further from the typical form.

Specimens from **Islay**, collected in May and August (at first referred, *loc. cit.*, to *A. s. sylvaticus*), are much like *maclean* in general appearance and colour; they are, however, slightly smaller, with smaller feet, relatively longer ears and tail. The **skull** is distinguished by its smaller size, the average (although large ones occur) being not greater than in *s. sylvaticus ;* in its greater zygomatic and inter-orbital widths, broader and deeper brain-case, and larger bullæ, it makes a still nearer approach to *h. hebridensis* than does the Jura form.

(5) *A. hebridensis fiolagan*, Hinton.

1914. Apodemus hebridensis fiolagan, Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 131 ; described from the island of Arran, Inner Hebrides ; type specimen, a male, No. 15.5.29.16 of the British Museum collection.

1913. Apodemus sylvaticus sylvaticus, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Proc. Zool. Soc.*, London, 1913, 835.

Celtic name :—(Local ; in Arran)—*Fiolagan* (Alston).

Distribution :—The island of Arran, Inner Hebrides.

Description :—This is a large mouse approaching *h. hebridensis* in size, in which the feet and tail are rather shorter, and the ears no larger than in the typical form. In **colour** the back is rather rufous, though considerably darker than in *cumbræ ;* the ventral surface is (in the typical series of eight from Brodick, Arran) silver, darkened slightly by the bases of the hairs, with hardly a trace of the pectoral spot ; the line of demarcation is clearly defined. In a female from the cliffs near King's Caves, Arran, there is a bright pectoral spot which is continued backwards as a median wash of yellow. The **skull** is a little smaller than in *h. hebridensis*, though larger than in *cumbræ ;* its chief peculiarity is the unusual lengthening of the pterygoid region, the post-molar length being long, as in the skulls from Tiree and Jura, while the bullæ are relatively smaller than in any other sub-species of *hebridensis ;* it differs from *h. hebridensis* further in the slightly wider nasals, slightly greater palatal length, shorter diastemata, smaller incisive foramina, broader masseteric plates, and longer molar series. The differences noted appear to be correlated with the greater muscular needs of a rather more powerful dentition.

DIMENSIONS IN MILLIMETRES :—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
A. hebridensis hebridensis.				
Lewis, Uig—Collected by W. E. de Winton :—				
1. Male (the type), 8th Aug. 1894 . .	106	96	25	16
2. Do. 28th Aug. 1894 . . .	112	100	25	16
3. Female, 29th Aug. 1894 . . .	108	95	23·5	15
Maximum and minimum of 7 (3 males, 4 females) immature or adolescent .	96	82	24	13·5
Aug. and Sept. 1894	85	77	23·5	14·5
Garrynahine, Callernish, W. Lewis—Collected by D. Anderson, 5th to 10th April 1913 ; average of 7 . . .	90·43	85·8	23	14·8
Maximum (male)	98	95	24	14·5(15)

DIMENSIONS IN MILLIMETRES—*continued* :—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
A. hebridensis, hebridensis—contd.				
TARBET, HARRIS—D. Anderson :—				
1. Female, 20th April 1913 . . .	90	83	22·5	14·5
2. Do. 21st April 1913 . . .	85	79	23·5	14·5
STORNOWAY, N.E. LEWIS—D. Anderson :—				
Average of 14, March 1913 . . .	95·85	87·8	23·25	15·2
Maximum (male)	102	90	24	16
BUTT OF LEWIS—W. Eagle Clarke :—				
Adult pelage: 1. Male, 29th Sept. 1914 .	89·5	83	24	..
2. Do. 29th Sept. 1914 .	94·5	85·5	23·75	14·75
3. Female, 17th Sept. 1914	99·5	83·5	22·5	15
BARRA—(?*Sub-species*).				
1. Male (Col. Pinney), 8th Sept. 1895 .	99	84	24	15
2. ? (W. E. Clarke), 21st May 1906 .	102	91	23·5	15
SOUTH UIST—(?*Sub-species*).				
1. Male (D. Anderson), 14th May 1913 .	91	86	22	15[1]
2. Female (W. E. Clarke), 1st June 1906	90	80	21	15
EIGG—(?*Sub-species*).				
Collected by P. D. Montague :—				
1. Male, 29th March 1913 . . .	85	78	23	15[2]
2. Female, 29th March 1913 . . .	90	78	23	15
A. hebridensis hamiltoni.				
RUM—Five collected by D. Anderson, 5th to 7th June 1913 :—				
Male	105	91	24	15
Do.	95	89	24	15[3]
Female	110	91	24	15
Do.	105	100	25	16
Do.	104	97	24	15
Average of 5	103·8	95·6	24·2	15·2
A. hebridensis cumbræ.				
GREAT CUMBRAE—Collected by R. W. Sheppard :—				
1. Male (max. of series), 29th March 1912	95	92	23	16
2. Female (type), 29th March 1912 .	93	90	23	15
Average of 6 (4 male, 2 female) . .	93	90·3	22·8	15·4
GIGHA—(?*Sub-species*).				
1. Female (R. W. Sheppard), 22nd May 1912	100	85	22·5	15
TIREE—(?*Sub-species*).				
Average of 4 collected by Sheppard, 8th to 13th July 1912	102·5	84·25	23·1	13·5
Average of 6 in Royal Scottish Museum, collected Nov. 1906 and Feb. 1907 .	83·4	84·8	19·2	14·2
Maximum (male), 10th July 1912 . .	105	83	24	13(13·5)
A. hebridensis maclean.				
MULL—Five males collected by Sheppard in June 1912 :—				
1. Type, 22nd June	100	80	24	14·5
Average	97	87·4	23·2	14·4
Maximum	100	87 (92)	24	14·5(15)
JURA—(?*Sub-species*).				
Average of 8 collected by Sheppard in May 1912	97·6	78·5	22·6	14·5
Maximum (male)	100	(84)	22 (24)	14·5
ISLAY—(?*Sub-species*).				
Average of 9 (Sheppard and Royal Scottish Museum)	93·3	81·6	22·5	14
Maximum (female)	101	85 (88)	22(23·5)	14·5(15)
A. hebridensis fiolagan.				
ARRAN—Nine collected by Sheppard in April 1913 :—				
1. Male, 4th April (Type) . . .	105	83	24	15
Average	98·3	84·5	23·5	14·5

[1] Old, teeth much worn. [2] Not fully mature. [3] Type.

Habits :—In habits *A. hebridensis* is doubtless similar to *A. sylvaticus.* In Lewis the country people told de Winton (*Ann. Scott. Nat. Hist.*, 1895, 53) that mice entered their houses in the winter; they were unable to distinguish de Winton's specimens from these visitors.

CRANIAL DIMENSIONS OF *APODEMUS HEBRIDENSIS, HIRTENSIS,* AND *FRIDARIENSIS*:—

	APODEMUS HEBRIDENSIS.					*A. HIRTENSIS.*	*A. FRIDARIENSIS.*	
	hebridensis, W. Lewis.	*hamiltoni,* Rum.	*cumbræ,* Gt. Cumbrae.	*maclean,* Mull.	*fiolagan,* Arran.	St Kilda.	*fridariensis,* Fair Isle.	*grantii,* Mid Yell.
Number of Skulls measured :—	3	2	3	3	6	4	2	7
1. Condylo-basal length	23·5 to 24·7	25·1 25·5	22·8 to 23·5	23·2 to 24·2	22·6 to 24	25·5 to 27·1	25·4 25·7	23·3 to 25·1
Do. average	**24·13**	**25·3**	**23·16**	**23·73**	**23·51**	**26·17**	**25·55**	**24·37**
2. Occipito-nasal length	26·0 to 27·3	27·4 27·7	25·3 to 25·7	25·3 to 26·8	25·3 to 26·7	27·8 to 29·1	27·8 28·4	26·0 to 27·5
3. Zygomatic breadth	12·9 ,, 13·7	13·5 13·7	13·0 ,, 13·2	12·3 ,, 13	12·4 ,, 13·6	14·2 ,, 15	14 14	13·0 ,, 14·1
4. Inter-orbital breadth	4·1 ,, 4·3	4·2 4·2	3·8 ,, 4	4·0 ,, 4·2	3·9 ,, 4·4	4·1 ,, 4·3	4·1 4·4	4·0 ,, 4·3
5. Cranial breadth	11·4 ,, 12	12·2 12	11·6 ,, 12	11·3 ,, 11·7	11·5 ,, 11·9	12·5 ,, 12·9	12 12	11·4 ,, 12
6. Cranial depth (middle) . . .	8·2 ,, 8·6	9 9	8·2 (2)	8·1 (3)	8·1 ,, 8·4	8·2 ,, 8·7	8·5 8·4	7·9 ,, 8·6
7. Condyle to m^3	10·7 ,, 11·3	11·3 11·6	10·5 ,, 10·7	10·5 ,, 11·1	10·2 ,, 11·8	11·7 ,, 12·7	12 12	10·8 ,, 11·8
8. Condyle to front of bulla . . .	6·3 ,, 6·6	6·4 6·6	6·1 ,, 6·2	6·0 ,, 6·4	5·5 ,, 6·2	6·7 ,, 7	6·8 6·7	6·1 ,, 6·5
9. Nasal length	9·5 ,, 10·1	10·2 10·1	9·0 ,, 9·8	9·7 ,, 10·2	9·6 ,, 9·7	11·1 ,, 11·4	10·6 10·4	9·3 ,, 10·1
10. Nasal width	2·5 ,, 2·6	2·9 3	2·7 ,, 2·8	2·7 ,, 3	2·7 ,, 3·1	2·9 ,, 3·1	2·6 2·9	2·6 ,, 2·8
11. Palatal length	12·6 ,, 13·5	14 14	12·3 ,, 12·9	12·6 ,, 13·1	12·6 ,, 13·2	14·3 ,, 14·6	13·8 14	12·4 ,, 13·6
12. Diastema	7·0 ,, 7·3	7·5 7·8	6·5 ,, 6·8	6·9 ,, 7·4	6·6 ,, 6·8	7·7 ,, 8·1	7·5 7·5	6·4 ,, 7·4
13. Incisive foramina (length) . . .	5·6 ,, 6	6·2 6·2	5·2 ,, 5·8	5·7 ,, 6	5·2 ,, 5·7	5·9 ,, 6·4	6·2 6·5	5·6 ,, 6·3
14. Incisive foramina (width) . . .	1·7 ,, 1·9	1·9 1·8	1·7 ,, 1·8	1·6 ,, 1·7	1·6 ,, 1·8	1·9 ,, 2·3	1·8 2	1·7 ,, 1·9
15. Rostral breadth	4·3 ,, 4·8	4·8 4·9	4·3 ,, 4·5	4·3 ,, 4·6	4·3 ,, 5	4·5 ,, 4·6	4·5 4·8	4·5 ,, 5·2
16. Masseteric plate (least width) . .	2·4 ,, 2·7	2·6 2·7	2·3 ,, 2·6	2·2 ,, 2·7	2·5 ,, 2·8	2·8 ,, 3·2	3·3 3	2·6 ,, 2·7
17. Maxillary cheek-teeth . . .	3·8 ,, 4	3·9 4·1	3·7 ,, 3·8	3·7 ,, 3·8	3·8 ,, 4·1	4·1 ,, 4·2	3·7 4	3·7 ,, 3·9
Mandible length	15·1 ,, 15·8	16·5 15·6	14·5 ,, 14·6	14·1 ,, 14·7	14·6 ,, 15·2	16·6 ,, 17·5	15·8 16	14·6 ,, 15·5
Mandibular cheek-teeth . . .	3·8 ,, 4	4·1 4	3·6 ,, 3·7	3·6 ,, 3·8	3·7 ,, 4	3·8 ,, 4·2	3·7 3·8	3·6 ,, 3·9

Reductions: 1. = 100	100	100	100	100	100	100	100	100
2. = Average	110 to 110·5 **110·33**	109 109 **109**	110·5 to 111 **110·75**	109 to 110·5 **109·83**	110 to 111 **110·62**	107·5 to 109 **108·16**	109 110·5 **109·75**	109·5 to 112 **110·5**
3. = Average	54·9 to 55·3 **55·16**	54·0 53·8 **53·9**	55·8 to 57 **56·56**	52·4 to 53·7 **53·03**	52 6 to 58·4 **55·43**	55·0 to 56·1 **55·5**	55 54·5 **54·75**	54·1 to 57 **55·36**
4. = Average	17·4 to 17·8 **17·53**	16·7 16·5 **16·6**	16·35 to 17·5 **16·8**	16·8 to 17·7 **17·28**	16·5 to 18·6 **17·65**	15·5 to 16·9 **16·05**	16·1 17·1 **16·6**	16·2 to 17·6 **16·83**
5. = Average	48·5 to 49·5 **48·83**	48·6 47 **47·8**	50·8 to 51·2 **51**	47·5 to 49 **48·26**	49·0 to 51·3 **49·63**	46·9 to 49 **48·23**	47·2 46·7 **46·95**	46·1 to 50·2 **48·17**
6. = Average	34·4 to 35·5 **34·93**	35·9 35·3 **35·6**	35·8 to 35 9 **35·6**	33·4 to 34·8 **34·06**	34·6 to 35·9 **35·1**	31·8 to 33·8 **32·47**	33·4 32·7 **33·05**	32·7 to 34·9 **33·57**
7. = Average	45·4 to 45·7 **45·53**	45 45·5 **45·25**	45·2 to 46 **45·56**	45·2 to 46·6 **45·9**	45·1 to 47·1 **46·23**	45·9 to 48·1 **46·83**	47·2 46·7 **46·95**	46·0 to 47·3 **46·63**
8. = Average	25·5 to 28·1 **26·53**	25·5 25·9 **25·7**	26·4 to 26·7 **26·6**	25·6 to 26·4 **25·93**	24·3 to 25·9 **25·3**	25·1 to 26·5 **25·96**	26·7 26·1 **26·4**	25·5 to 27 **26·07**
9. = Average	40·4 to 41·3 **40·86**	40·6 39·6 **40·1**	39·4 to 41·7 **40·23**	41·6 to 42·1 **41·8**	40·0 to 42·5 **40·94**	42·0 to 43·6 **42·56**	41·7 40·5 **41·1**	39·4 to 40·5 **39·87**
10. = Average	10·3 to 10·6 **10·46**	11·55 11·8 **11·67**	11·8 to 12·05 **11·91**	11·6 to 12·6 **11·93**	11·4 to 12·9 **12·1**	10·7 to 11·8 **11·36**	10·2 11·3 **10·75**	10·4 to 11·5 **11·08**
11. = Average	53·6 to 54·6 **54·23**	55·8 55 **55·4**	53·9 to 54·9 **54·33**	53·8 to 54·2 **54·03**	53·3 to 56·2 **54·63**	53·9 to 56·1 **54·9**	54·3 54·4 **54·35**	53·1 to 54·8 **53·97**
12. = Average	29·5 to 30·1 **29·8**	29·9 30·6 **30·25**	28·5 to 29·3 **28·9**	29·4 to 30·6 **29·9**	27·9 to 29·2 **28·48**	29·5 to 31 **30·15**	29·5 29·2 **29·35**	27·4 to 30·4 **29**
13. = Average	23·8 to 24·8 **24·13**	24·7 24·3 **24·5**	22·8 to 24·7 **23·56**	24·4 to 25 2 **24·7**	22·6 to 23·7 **23·15**	22·3 to 24·1 **23·37**	24·4 25·3 **24·85**	24·0 to 25·5 **24·77**
14. = Average	7·25 to 7·7 **7·46**	7·57 7·1 **7·33**	7·2 to 7·9 **7·46**	6·7 to 7 **6·86**	6·7 to 8 **7·32**	7·2 to 8·5 **7·83**	7·1 7·8 **7·45**	6·9 to 8·15 **7·35**
15. = Average	18·3 to 19·4 **18·76**	19·1 19·2 **19·15**	18·5 to 19 7 **18·96**	18·1 to 19·4 **18·83**	18·4 to 20·9 **19·53**	16·6 to 17·7 **17·3**	17·7 18·7 **18·2**	19·1 to 21 **19·93**
16. = Average	10·2 to 10·9 **10·46**	10·35 10·6 **10·47**	9·8 to 11·2 **10·66**	9·5 to 11·2 **10·26**	10·6 to 12·4 **11·28**	10·6 to 11·8 **11·27**	13 11·7 **12·35**	10·4 to 11·15 **10·73**
17. = Average	15·7 to 16·2 **16·03**	15·5 16·1 **15·8**	16·2 to 16·35 **16·25**	15·5 to 16·4 **16**	15 8 to 17·1 **16·6**	15·5 to 16·1 **15·85**	14·6 15·6 **15·1**	15·0 to 16·7 **15·6**

THE ST KILDA FIELD MOUSE.

APODEMUS HIRTENSIS, Barrett-Hamilton.

1899. MUS HIRTENSIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1899, 81, pl. ix., fig. 1, reprinted in *Ann. Scott. Nat. Hist.*, 1899, 129; described from St Kilda: type specimen No. 94.7.16.1 of British Museum collection, Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, i.; (*Apodemus*) Miller, *Catalogue*, 825, 1912.

1900. MUS SYLVATICUS HIRTENSIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404; Johnston; Millais; Trouessart.

Distribution and history:—This field mouse is only known from St Kilda, upon which mice of some sort have been long known to exist (Seton, *St Kilda, Past and Present*, 1878, 132); it inhabits the main island—Hirta—and the adjacent islets, Soay and Dun. Steele Elliott, in an account of a visit to St Kilda given at a meeting of the Birmingham Nat. Hist. and Philosophical Society on 13th November 1894 (*Proceedings*, April 1895, 135; and *Zoologist*, 1895, 282), mentioned the occurrence of a peculiar field mouse on the island. Unfortunately he secured only one specimen—"by far the most interesting of all my captures"—which was placed in spirit and forwarded to Harting. It was thought advisable to wait for further specimens before deciding on the status of this animal; but, for some reason, Harting failed to record the capture in the *Zoologist*. In January 1895 de Winton mentioned (*Ann. Scott. Nat. Hist.*, 1895, 53) the occurrence of "The Wood-Mouse (*Mus sylvaticus*)" on St Kilda. Later, when de Winton described his *Mus hebridensis* (*Zoologist*, October 1895, 369), Steele Elliott, not suspecting the possibility that *hirtensis* and *hebridensis* might be distinct, wrote (*Journ. cit.*, 1895, 426, and 1896, 76) claiming priority for the discovery. De Winton at once pointed out (*Journ. cit.*, 1895, 446) that his own description of *hebridensis* was not applicable to the mouse taken by Steele Elliott at St Kilda. In 1898 Barrett-Hamilton's interest was awakened by the remarkable appearance of Steele Elliott's mouse, and he induced Henry Evans to land on St Kilda and trap further specimens. On the material so obtained Barrett-Hamilton based his *Mus hirtensis*.[1] The habits of this mouse have been described by J. Waterston (*Ann. Scott. Nat. Hist.*, 1905, 199), and Eagle Clarke's recent work has greatly extended our knowledge of it (*Journ. cit.*, June 1914, 124).

Description:—*A. hirtensis* is a large mouse with long feet and rather short ears, distinguished from its closest ally, *A. hebridensis*, by its larger size, relatively longer ears, occasionally darker ventral coloration, and considerably larger skull.

The **colour** of the back and flanks is nearly as in *sylvaticus;* the under-surface is sometimes heavily washed with buff or yellowish-brown, which tint merges laterally in that of the flanks, so that there is no well-defined line of demarcation. It seems, however, that this is not the normal coloration, for Mr Eagle Clarke has found (*op. cit.*), from a long series of specimens taken in the months of September and October, that in about two-thirds of the adults, "and many of the immature ones, the throat, chest, and abdomen are white, and only washed with brown along the narrow median ventral line. As a result the demarcation between the peppery reddish-brown upper-, and the pale under-surface is pronounced in most examples, and renders the species very similar to" *A. sylvaticus.* "About one-third of the adults and the majority of the younger specimens have the under-surface more or less strongly washed with buff." The dark dorsal line is well developed. In young individuals the backs are greyer, the bellies more rufous than in adults (see Steele Elliott's description of the type specimen, *Zoologist*, 1895, 426). In the **skull** the smooth and rounded brain-case is rather depressed; the post-molar length is not shortened as is usual in *hebridensis*, though the bullæ are rather small; and the nasals are relatively long (see proportional measurements in the table at p. 538). The **cheek-teeth** are as in *sylvaticus.*

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[1] Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, 1.

Dimensions :—

	Head and body.	Tail.	Hind foot.	Ear.	Condylo-basal length.
1. Male, immature (type of species, No. 94.7.16.1 of British Museum collection)	81	85	25	..	24·5
2 Male, Henry Evans	107	91	24·5	17	23[1]
3. Male, largest recorded by W. Eagle Clarke	129	109	26·5	17·5	..
4. Female, Henry Evans	110	94	24	15 (?)	..
5. Female, largest recorded by W. Eagle Clarke	126	110	25·5	19·5	..
6. Average—20 males (Eagle Clark) .	109·8	94	25·1	17·5	..
7. Average—22 females (Eagle Clark) .	112	107	24·9	17·2	..

[1] Cheek-teeth only slightly worn.

Remarks ;—Specimens with head and body between 100 and 113 mm. are probably adolescent; full-grown (which in most *Muridæ* means "senile") specimens are those with the head and body near 120 mm.

For cranial dimensions, see table at p. 538 above.

Status :—*A. hirtensis* is a well-marked member of the *sylvaticus* group. The latter has been established in Britain since the late Pliocene (Forest Bed), a fact which goes far to support the view that this species is truly indigenous upon St Kilda. The characters of *A. hirtensis* are probably to be regarded as the results of insular specialisation. For remarks upon the position of *hirtensis* within the *sylvaticus* group, see above under Genus.

Habits :—Mr Eagle Clark says that this mouse is most abundant where coarse grass prevails, although it is to be found almost everywhere, as in the crofted area, the neighbourhood of houses, on the faces of the cliffs, and on the sides and tops of the hills. It finds congenial retreats in the rough stone-built "cleits," and in the walls surrounding the crofts. Some fine specimens were captured in a store close to the water's edge. On the island of Dun it was found dwelling in fissures and holes on the face of the rocks, where the very luxuriant grass was growing close by on ledges or at the foot of the crags. Here its presence was betrayed by its numerous runs, and by the seeds of grass on which it feeds. Seeds of *Carex flava* were found in a hole a few inches deep on a hillside in Hirta; these seeds form perhaps the chief food. It appears to be much addicted to cannibalism; because of this, many specimens were completely destroyed before the traps could be visited. It appeared to be entirely nocturnal. Like *sylvaticus* and other mice, it attains sexual maturity at an early moment; the nursing females caught in September 1910 and 1911 varied greatly in size, some being evidently quite young creatures. In September 1910 no pregnant females and no young smaller than half-grown were taken. In September 1911 Mr Eagle Clark obtained several quite young mice. A female caught on 14th September contained seven fœtuses; another younger one taken on the 18th, had six less developed fœtuses. Mr Waterston describes two nests, "neither of them typical." He found males twice as numerous as females. Dissections showed the average number of fœtuses to be six. Both sexes appeared to be subject to disease, especially of the liver, which was spotted by colonies of *coccidia*, and also infested by a Cestode. The people said that on Dun these mice are subject to variation in colour, and one with some white markings was brought to Mr Waterston.

THE FAIR ISLE FIELD MOUSE.

APODEMUS FRIDARIENSIS (Kinnear).

Synonymy under sub-species.

Distribution:—Fair Isle and Shetland Islands, where it occurs on Yell, and possibly on Mainland.

History and status:—This Field Mouse was discovered on Fair Isle by Kinnear, who described it in 1906 as a sub-species of *A. sylvaticus*. In his *Catalogue* Miller has accorded this form full specific rank. The differences between *fridariensis* and *sylvaticus* are scarcely such as would entitle the former, if it stood alone, to be considered as anything more than a sub-species of the latter. In the summer of 1913, Ogilvie-Grant found a Field Mouse living on the island of Yell. His specimens, although differing from typical *fridariensis* in some respects, are clearly more nearly related to the Fair Isle mouse than to *A. sylvaticus*, and they have been described as a sub-species (*A. f. grantii*). A large Field Mouse also occurs on Mainland, Shetland, and this, when better known, will probably be found to belong to *fridariensis* also. It is, therefore, useful to retain *fridariensis* as a full species, because by doing so we are enabled to indicate the relationship of these insular Field Mice in a convenient manner.

As Kinnear pointed out, *A. fridariensis* has branched off from *A. sylvaticus* in a different direction from that followed by the Hebridean species, *hebridensis* and *hirtensis*; in the present species there is no increase in the relative size of the foot, and the ventral surface shows no tendency to become buff, and so cause the obliteration of the line of demarcation.

Description:—*A. fridariensis* differs from *A. sylvaticus* externally in its larger size, darker coloration, shorter ears, and relatively smaller palmar and plantar pads. The skull is characterised by its exceptionally slender rostrum; in the mandible the coronoid processes are usually small. Further details will be found below under the sub-species.

(1) *Apodemus fridariensis fridariensis* (Kinnear).

1906. MUS SYLVATICUS FRIDARIENSIS, N. B. Kinnear, *Ann. Scott. Nat. Hist.*, April 1906, 68; type a male in the Royal Scottish Museum, Edinburgh; described from Fair Isle, Shetlands; Trouessart.

1912. APODEMUS FRIDARIENSIS, G. S. Miller, *Catalogue of the Mammals of Western Europe*, 825.

1914. A(PODEMUS) F(RIDARIENSIS) FRIDARIENSIS, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 132.

Distribution:—Fair Isle.

Description:—The general colour of the upper parts is like that of *A. sylvaticus*, but the long black hairs of the back and flanks are more numerous and give the fur a looser and harsher texture; these hairs cause the back to be more conspicuously clouded with black, and impart to the flanks a much darker, richer, and more heavily lined appearance. The line of demarcation along each flank is very regular in its course and very clearly defined. The ventral surface is of a uniform dull bluish-white throughout; it shows no trace of a buffy suffusion, and usually no trace of a pectoral spot; the latter is occasionally represented by a few brownish hairs. The feet are whitish. The upper surface of the tail is dusky, in sharp contrast with its whitish lower surface.

The skull is large, and has the brain-case relatively long and narrow; the temporal ridges are occasionally (*e.g.*, B.M., 6.11.18.4) sharply defined in old age, although they never impart such an angular appearance as is seen in old skulls of *A. flavicollis*. The rostrum is long and slender; the masseteric plates of the zygomata are relatively broad, and project further in advance of the upper zygomatic roots than they do in *A. sylvaticus*. The coronoid processes of the mandible are very short and slender. The cheek-teeth are as in *A. sylvaticus*.

For external dimensions, see table at p. 544; the cranial measurements are given above in the table at p. 538.

(2) *Apodemus fridariensis grantii* (Hinton).

1914. APODEMUS FRIDARIENSIS GRANTII, M. A. C. Hinton, *Ann. and Mag. Nat. Hist.*, July 1914, 132; type an old male, No. 15.5.31.4 of British Museum collection; described from the island of Yell, Shetland.

Local name:—*Hill Mouse.*

Distribution:—Yell, and possibly Mainland, Shetland.

Description:—This sub-species is distinguished from typical *A. fridariensis* by its slightly smaller size and relatively shorter tail. In colour it is quite like the typical form, save that a small pectoral spot appears to be constantly present, and the contrast between the upper and lower surfaces of the tail is much less striking. The line of demarcation on each flank is very regular and distinct.

The skull is slightly smaller than in the Fair Isle form. The brain-case is shorter and rounder, more like that of *sylvaticus* in form; the nasals slope more gently forwards, and the dorsal profile appears to be flatter and less convex throughout. The masseteric plates of the zygomata are much narrower and do not project so far in advance of the bridges over the infra-orbital canals. The bullæ are smaller. In the mandible the coronoid processes are even more slender; the angular processes are exceptionally long, and specimens may be readily distinguished by this character from the mandibulæ of all other European forms of *Apodemus.* For external and cranial dimensions, see tables below and at p. 538 respectively.

DIMENSIONS IN MILLIMETRES:—

	Head and Body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
FAIR ISLE.—*A. fridariensis fridariensis*:—					
1. Male (N. B. Kinnear), paratype, 5th Sept. 1905	115	106	23	15	35
2. Do. do. 9th Sept. 1906	113	102	24	17	..
3. Do. do. 16th May 1906	106	..	24	16	..
4. Do. (Duchess of Bedford), 10th Oct. 1910	107	105	25	16	..
5. Female (N. B. Kinnear), 14th Sept. 1906	111	..	24	17	..
6. Do. (Duchess of Bedford), 10th Oct. 1910	105	100	25	16	..
7. Do. do. 10th Oct. 1910	99	95	25	16	..
YELL, SHETLAND.—*A. f. grantii*:—					
1. Male (W. R. Ogilvie-Grant), 22nd June 1913	104	91	23	16·5	..
2. Do. do. 22nd June 1913	100·5	87	23	16·5	..
3. Do. do. 25th June 1913	98	79	24	15·5	..
4. Do. do. 25th June 1913	105	80	25	15·5	(Type)
5. Do. do. 22nd June 1914	99	96	24·5	16	..
6. Do. do. 25th June 1914	110	94	25	17	..
7. Do. do. 25th June 1914	106	92	24	16	.
8. Do. do. 25th June 1914	102	100·5	24	17·5	..
9. Female, do. 22nd June 1913	97	96	23	15·5	..
10. Do. do. 22nd June 1914	94	92	24	15·75	..
Average of 6 adults of *A. f. fridariensis* .	109·5	103·2	24·1	16·1	..
Average of 10 adults of *A. f. grantii* . .	101·5	91·75	23·95	16·17	.

THE YELLOW-NECKED FIELD MOUSE.

APODEMUS FLAVICOLLIS (Melchior).

1834. MUS FLAVICOLLIS, Melchior, *Den Danske Staats og Norges Pattedyr*, 99; described from Sjælland, Denmark; de Winton, *Zoologist*, December 1894, 441; Lydekker; (*Apodemus*) Miller (*Catalogue*).

1874. MUS SYLVATICUS, Lilljeborg, *Sveriges og Norges Ryggradsdjur*, i., 263; Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 404, 406, 408 (in part; sub-species *M. s. typicus*, *cellarius*, *princeps*, *wintoni*); Fatio, Trouessart, Winge, and Collett (all in part).

For full **Synonymy** of species and typical sub-species, see Miller's *Catalogue.*

History:—In 1834 Melchior described his *Mus flavicollis* from material collected in Sjælland, Denmark; in 1836 the editor of Wiegmann's *Archiv für Naturgeschichte* (1836, 78), when reviewing Melchior's book, expressed his decided opinion that *A. flavicollis* was nothing but a large variety of *sylvaticus*, and for upwards of sixty years subsequent writers appear to have been satisfied with this opinion, In 1894 de Winton studied some giant Field Mice from Herefordshire and came to the conclusion that they, together with a specimen from Oundle, Northamptonshire, and another from Tharand, Saxony, were distinct from *A. sylvaticus*, and that they were referable to Melchior's species. Barrett-Hamilton, finding that Field Mice from Hilleröd, in Sjælland, Denmark (a locality almost topotypical for *flavicollis*), agreed with typical *sylvaticus* from Upsala, regarded, in 1900, Melchior's name as a synonym of *sylvaticus typicus;* he was not then aware that two forms of Field Mouse were living in Sjælland; at the same time he distinguished, as sub-species of *sylvaticus*, *Mus cellarius*, J. V. Fisher (*Zool. Gart.*, vii., 153, 1866), described from cellars at or near St Petersburg, Russia, and his own *M. s. princeps*, described from Bustenari, Rumania; de Winton's mice were described as a sub-species, *wintoni*, of *sylvaticus* also. With much more material at his disposal Miller has concluded that the giant Field Mouse is specifically distinct from *A. sylvaticus*, and that this large species is the *Mus flavicollis* of Melchior. Miller further regards the British *A. f. wintoni* as a distinct sub-species from the typical *A. f. flavicollis* of the Continent. His views are adopted in the present work.

Two recent authors of great eminence, Winge and Collett, do not think *A. flavicollis* to be a valid species. The former (*Danmarks Pattedyr*, 94) regards *flavicollis* as simply a well-grown *sylvaticus;*[1]

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[1] "There does not appear to be any occasion to speak even of a true racial distinction; the difference is most likely dependent upon accidental better or worse condition."

the latter regards it as one of the phases of *sylvaticus*, which "is a polymorphic species." According to both writers, *sylvaticus* and *flavicollis* intergrade; and both may be found mingled in the same colony. Still, the broad fact remains, according to Collett, that in southern Norway the vast majority of the Field Mice of the coastal lowlands are typical *sylvaticus*, the vast majority of those dwelling in the high mountain pastures are typical *flavicollis*, while the intermediate ground between the two situations is the most usual habitat of the intermediate mice. Further, it is a remarkable fact that although Britain has been occupied, but perhaps not continuously, by members of the *sylvaticus* group since the Upper Pliocene (Forest Bed) period, and that although their fossil remains have been found in several horizons of widely different ages, it is not until the late Pleistocene of Ightham that remains of a form (*A. lewisi*, Newton) similar to, if it be not identical with, *flavicollis* are met with. It is also a fact that *A. flavicollis* has not found its way into any of the islands other than Britain. The status of *A. flavicollis* is, as is the case with other Field Mice of the *sylvaticus* type, undoubtedly a difficult thing to determine; but the facts just cited seem to support the opinions of de Winton and Miller. Some small proportional differences in certain regions of the skull, described below, also support the claims of *flavicollis* to specific recognition.

Distribution:—*A. flavicollis* is distributed throughout Central Europe, ranging from at least southern Skandinavia and Finland southwards to the Pyrenees and Alps, and from Britain eastwards to Greece, Rumania, and western Russia. How far to the north its range extends is unknown. It is represented in the Himalayas by close allies, and the range of the group may extend still further eastwards.

In Norway, according to Collett, *A. flavicollis* is the predominant Field Mouse of the wooded valleys of the interior and the adjoining sub-Alpine tracts; *A. sylvaticus*, on the other hand, being restricted principally to the lowland coastal region. Mice which appear to be intermediate in character are met with in the intervening belt of country. *A. flavicollis* ascends to the mountain pastures, or a height of about 3000 feet. From Fatio's description of the Swiss Field Mice (p. 212) it would appear that *flavicollis* is the prevalent mountain form in the Alps; he mentions specimens taken in the Oberland at a height of about 1900 m., and others from the Engadine at about 2500 m.; from the context it would appear that these were *flavicollis* rather than *sylvaticus*.

In **Britain** it is not known to occur further north than Northumberland; the British form is regarded as sub-specifically distinct from the typical continental *flavicollis*.

Distribution in time:—As stated above, no trace of this species has been discovered in deposits older than the late Pleistocene. A large lower jaw (16·2 mm. long) mentioned by Woldrich (*Sitzungsb. Akad. Wien. math.-nat. Cl.*, 84, Abt. i., 216, 1881) from the fissure deposit of Zuzlawitz, Bohemia, appears to be referable to this species. From Britain, Newton (*Quart. Journ. Geol. Soc.*, l., 195, 1894, and lv. 424, 1899) has described, first under the name of *Mus abbotti* (not of Waterhouse) and subsequently as *Mus lewisi*, remains of a large Field Mouse from the fissure deposit of Ightham (see above). A lower jaw from one of the upper strata of Kent's Cavern, Torquay, yielding a typical assemblage of late Pleistocene rodents, is also referred to *A. lewisi;* and skulls of the same form have been found in strata of similar age in the Happaway Cave, Torquay, and the Wye Cave, Forest of Dean (Hinton, *Ann. and Mag. Nat. Hist.*, June 1915, 582). The fossil species clearly is closely related to *A. flavicollis*, and may well be identical with it; its real status, in the absence of good skull material, cannot at present be determined, and it is better for the moment, therefore, to regard *A. lewisi* as a distinct form.

Description:—The Yellow-necked Field Mouse is distinguished from *A. sylvaticus* by its larger size (head and body of adults, 100 to 115; hind foot, 23 to 27; condylo-basal length of skull, 25 to 28·8 mm.), more intense and purer coloration, and by some cranial characters.

The **colour** of the back and sides is brighter, with redder tints than in *sylvaticus;* the belly is white, without any trace of a buffy suffusion, and the lateral line of demarcation is always sharply defined. The pectoral spot of yellowish-brown is usually larger than in *sylvaticus*, and is often extended laterally so as to form a complete collar.

The **skull** in adult or old animals (teeth half-worn or more) is distinguished from that of *sylvaticus* of equal age by its larger size and more massive build. The temporal ridges are relatively strongly developed, and impart an appearance of angularity to the skull, as a whole, which is never seen in *sylvaticus;* anteriorly these ridges are continued almost to the lachrymal as sharp superciliary margins which are sufficiently salient to produce a slight but evident longitudinal furrow upon the frontals. The auditory bullæ are relatively large. The diastemata are proportionally about as long as in *sylvaticus*, but the incisive foramina are relatively shorter (see table at p. 518 above).

The **cheek-teeth** are a little larger than in *sylvaticus*, but they are of the same form and structure. In m_1 the anterior "accessory" cusp (p. 501 above) is frequently of small size, and is occasionally so inconspicuous that, in moderately worn specimens, it may appear to be quite absent. Newton called attention to this character in his description of the pleistocene *A. lewisi.*

Geographical variation:—Two sub-species are now recognised. One of these, the typical continental form, *A. f. flavicollis*, has the ventral surface usually of a pure white colour; its pectoral spot is often not sufficiently developed to form a complete collar. The other is the British *A. f. wintoni*, described below. Collett says that in the form living in southern Norway the reddish-yellow pectoral belt is seldom wanting, and that it is often prolonged in a short point down towards the belly; this race would thus appear to make a closer approach towards the British form than do the specimens from Central Europe.

The British sub-species is :—

DE WINTON'S FIELD MOUSE.

APODEMUS FLAVICOLLIS WINTONI (Barrett-Hamilton).

1900. MUS SYLVATICUS WINTONI, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 1900, 406; described from Graftonbury, Herefordshire; type specimen, a male, No. 0.3.12.1 of British Museum collection; Trouessart; Johnston; Millais.

1894. MUS FLAVICOLLIS, de Winton, *Zoologist*, 441, December; Lydekker.

1912. APODEMUS FLAVICOLLIS WINTONI, Miller, *Catalogue*, 831.

History:—Pennant (*Quad.*, ii., 184, ed. 3, 1793)[1] states that the "Field Rat" has the "breast of an ochre colour; belly white; length, from the tip of the nose to the tail, 4½ inches; tail, 4 inches"; this description appears to have been based upon a specimen of the present form, and not upon *sylvaticus*. Similarly, the dimensions given by Shaw, Desmarest, and Bell (ed. 2, 296) appear to be derived from *wintoni*, and most of the older writers seem to have regarded this mouse as a full-grown or finely developed *sylvaticus*. Jenyns (*Man. Brit. Vert.*, 31, 1835), however, called specific attention to "a larger variety, measuring 4½ inches in length, exclusively of the tail, which is 4 inches," sometimes met with in woods. The history of modern knowledge of this form, dating from de Winton's paper of 1894, has been dealt with above under the species.

Distribution:—This mouse is only known from South Britain, in which it appears to have a wide but sporadic distribution. Originally described from Herefordshire and Northamptonshire, it is now known to occur at various localities in Sussex, Surrey, Kent, Middlesex, Essex (Dr H. Laver and G. Dalgleish, *in lit.*), Suffolk (Southwell, *Zoologist*, 1903, 150), Northumberland, Worcestershire (Pocock, *Journ. cit.*, 1901, 423), Cornwall, Shropshire, near Oswestry (Dumville Lees in Forrest), Brecon (at Llyswen, Phillips), and Denbigh (Llanrwst, Forrest, *North Wales*, 50).

Where present this mouse is usually abundant, its colonies being, if always distinct from, frequently in close proximity to those of *sylvaticus*. De Winton (*op. cit.*, 442) states that all the specimens (of both species) of which he records the dimensions "were caught within an area of thirty acres, but the species did not intermingle; yet there was no natural boundary or observable difference in the soil on which they were found." Dalgleish (*in lit.*, 17th November 1910) found it common in parts of Surrey, where it occurred with *sylvaticus*. L. E. Adams (*MS.*) finds it at Reigate associated with *sylvaticus* and with mice which he considers to be intermediate between the two forms.

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[1] Also in *Brit. Zool.*, ed. 1 (folio), 1766, 49.

A. f. wintoni is not known from Scotland, Ireland, nor any of the smaller islands.

The differential distribution of *wintoni* and *sylvaticus* within the British area offers a certain analogy with that of the Common and Pygmy Shrews. The restricted distribution of *wintoni*, coupled with the fact that field mice of this type are not known in Britain before the late Pleistocene, suggests that it is a comparatively recent immigrant. The facts are susceptible of a different explanation, however. The existing English stock of *sylvaticus* is quite possibly no older, since it may also have arrived here in late Pleistocene times (see p. 510 above); the *sylvaticus*-like forms from the Upper Pliocene and the earlier Pleistocene are in all probability distinct. From such earlier and distinct stocks certain of the insular species (e.g. *A. hirtensis*) may well have descended. The wider range of the modern stock of *sylvaticus* in Britain and Ireland may in this case be due merely to some inherent advantage as a colonist possessed by the smaller over the larger species. The fact that in Norway and Switzerland *flavicollis* is the mountain form and *sylvaticus* is the lowland species lends some support to this latter hypothesis. Further close anatomical and palæontological research will probably throw light on this interesting question.

Description:—*A. f. wintoni* usually possesses a well-defined and complete ochraceous breast-band or collar "about 8 mm. broad, passing along the chest immediately in front of the fore legs, with a cross or longitudinal stripe in the centre extending forward about 5 mm., and back along the sternum about 10 mm., where it is entirely lost" (de Winton, *op. cit.*, 442). The fur would appear to be somewhat thinner than in the continental form, and the dark bases of the hairs usually impart a more marked slaty tinge to the white under-parts.

Young:—The juvenal pelage is plumbeous, as in *sylvaticus*. De Winton (*op. cit.*, 443) stated that some trace of the pectoral collar could be seen in specimens in this pelage; this is confirmed by Adams, who finds that all young in the first pelage show a collar of a dark shade across the grey chest. Compared with the first pelage of *sylvaticus*, the juvenal coat of *wintoni* is much whiter ventrally (L. E. Adams, *MS.*).

The **skull** and **teeth** have been described above under the species. For cranial dimensions, see table at p. 518.

De Winton (*op. cit.*, 443) mentions that the tail is made up of 30 vertebræ, instead of 27 as in *sylvaticus;* but de l'Isle (*Ann. Sci. Nat. Zool.*, 1865, iv., 215) has pointed out how variable the skeleton of the Field Mouse is in such respects. The tail is stated by Adams (*in lit.*) to be relatively robust as compared with that of *sylvaticus.*

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
SEXUALLY IMMATURE (OF BOTH SEXES):—					
Caught and measured by L. E. Adams—					
1. Female, in first pelage, 10th Oct. 1911	68	64	20·5	..	..
2. Male, do. 25th July 1911	69	71	21	13	10
3. Do. do. 29th Oct. 1909	70	70	20·5	..	..
4. Do. do. 9th July 1909	72	73	22	..	..
5. Female, pelage changing, 7th Aug. 1909	86	92	23	..	..
6. Male, do. 10th Feb. 1905	89	85	25	..	..
7. Female, do. 30th Dec. 1904	90	78	23	..	20
8. Male, do. 8th June 1909	91	100	22	..	..
9. Do. pelage almost ad., 27th Feb. 1905	95	92	25	..	22[1]
10. Female, imperforate but perhaps adult, Ludlow, Salop, 1st March 1913	104	108	23	17	31
Herefordshire, young in grey pelage (de Winton, *Zoologist*, 1895, p. 370), male .	68	60	20	16	..
Do. do. female	81	84	21	16	..
Do. do. do.	84	83	22	16	..
Do. do. male	90	83	24	17	..
SEXUALLY MATURE MALES:—					
Caught and measured by L. E. Adams at Reigate, Surrey—					
1. 10th Dec. 1904	117	115	25	..	34
2. 30th Dec. 1904	117	116	25	..	35·5
3. 8th June 1909	91	100	22	..	..
4. 26th June 1909	114	124	24·5	..	..
5. 9th July 1909	103	112	24	..	..
6. 11th July 1909	98	108	24	..	..
7. 27th Sept. 1909	98	106	24	..	..
8. 8th Oct. 1909	100	114	25	..	..
9. 29th Oct. 1909	103	110	25	..	..
10. 29th Oct. 1909	100	108	24	..	..
11. 29th Oct. 1909	94	94	23	..	..
12. 3rd Dec. 1909	93	102	24	..	..
13. 7th Dec. 1909	95	98	23	..	..
14. 7th March 1910	103	112	23·5	..	..
Bishop's Stortford—					
15. 8th May 1911	104	118	22·5	..	..
16. 26th May 1911	114	122	24	..	34
17. 26th May 1911	106	118	24	..	..
Reigate—					
18. 24th May 1912	100	120	24	17	32
Ludlow, Salop—					
19. 1st March 1913	105	97	23	16	33
Herefordshire (W. E. de Winton, *Zoologist*, 1895, p. 370)	110	112	24	18	..
Richmond Hill, Surrey (G. Dalgleish, *Zoologist*, Nov. 1904, p. 425)	119	115	25	..	33·6[2]
Woolpit, Suffolk (W. D. Parker) .	112	120	24	..	..
Average of 22 (approximate) . .	105	110·8	24	17	33·7

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[1] Testes quite small; pelage almost adult.

[2] Tail imperfect, foot with claws: neither included in average; weight stated as "1 oz., plus 1 shilling piece" $=1\frac{3}{16}$ oz.

DIMENSIONS IN MILLIMETRES—*continued*:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.	Weight in grammes.
SEXUALLY MATURE FEMALES:—					
Caught and measured by L. E. Adams at Reigate, Surrey—					
1. 30th Dec. 1904	100	100	23	..	23
2. 24th Aug. 1906	85	98	24	..	22
3. 22nd July 1909	90	104	22	..	..[1]
4. 10th Oct. 1911	94	108	23	16	31[2]
Ludlow, Salop—					
5. 1st March 1913	105	107	24	17	31[3]
Herefordshire (W. E. de Winton, *Zoologist*, 1895, p. 370)	108	108	24	18	..
Do. do.	110	115	23	13	..
Do. do.	115	112	24	18	..
Norton, Worcestershire (R. I. Pocock, *Zoologist*, 1901, p. 423), in spring . .	108	114	22	19	..
South Herefordshire (G. A. Burney), 28th March 1914	101	100	23	15·5	..
Average of 10	101·6	106·6	23·2	16·5	..
Graftonbury, Hereford: average and extreme measurements of 6 adults of both sexes; Miller, *Catalogue*:—					
Minimum	102	92	23	17	..
Maximum	115	115	25	19	..
Average	108·6	107·5	24·1	17·6	..

[1] 6 embryos. [2] Suckling. [3] Perforate; practically mature.

Habits:—The general habits of this mouse are, no doubt, like those of *sylvaticus*. Not infrequently, however, it takes up an abode in houses. Thus Mr Adams says that it "occasionally frequents buildings"; Dr H. Laver informed us of four that were killed in a storeroom at Colchester in 1904; Mr G. Dalgleish (*in lit.*) describes three females caught in a storeroom in his house at Midhurst, Sussex, early in November 1910, and he states that in the winter of 1909 a number were taken in an outhouse, where potatoes were stored, at Godalming, Surrey. Lastly, Mr J. F. Davison sent three caught on 26th February 1913 in a ground-floor room, used as a larder, in his house at Ludlow, Shropshire; he mentions (*in lit.*) that he had also caught this mouse, together with *Microtus hirtus*, in the cellars; that in one part of his stables *wintoni* abounded, while next door, and

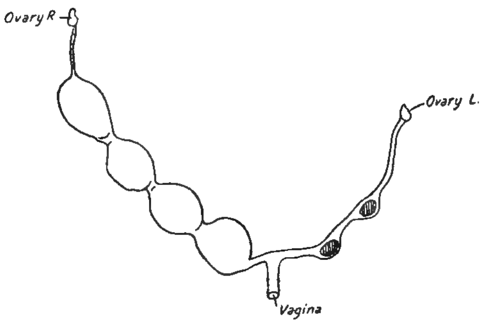

FIG. 88.—*A. f. wintoni:* DISSECTION OF UTERUS, SHOWING SUPERFŒTATION. (L. E. Adams.)

in the kitchen of the house itself, there seemed to be nothing but rats in plenty.

Like *A. sylvaticus*, *wintoni* probably breeds throughout the greater part of the year. Mr Adams has found new-born young in July, October, and November; he once met with a litter of six. We are indebted to the same gentleman for a sketch of what appears to be a well-marked case of superfœtation (Fig. 88); the right uterine cornu contained four relatively well-developed embryos, while in the left cornu were two much smaller.[1]

According to Melchior, the typical form lays up winter stores and sometimes enters houses and corn-ricks in winter. Its pairing season begins in February and continues at intervals throughout the summer, there being from four to eight young in a litter. He makes the remarkable assertion that if a female be the tenant of a room and without a mate, she will pair with the House Mouse; the progeny of such a union are described as recognisable hybrids showing some similarity to each parent, but being characterised constantly by their long hind feet and dark-coloured soles.

GENUS MICROMYS.

1841. MICROMYS, A. Dehne, "*Micromys agilis, kleinmaus, ein neues Säugthier der Fauna von Dresden*," 1; based on *Micromys agilis* of Dehne = *Mus soricinus* of Hermann = *Micromys minutus soricinus;* Thomas, *Ann. and Mag. Nat. Hist.*, May 1905, 492 (part); Miller (*Catalogue*).
MUS of most writers prior to Thomas, 1905, quoted above.

The genus *Micromys* is now restricted to the Harvest Mice. These are regarded as belonging to a single species, *M. minutus*, which, notwithstanding a wide distribution extending from Britain through the central parts of Europe and Asia to Japan, appears to be subject to surprisingly little geographical variation.

In all the essential features of its organisation this genus is not unlike *Apodemus*, and there can be little doubt, although the positive evidence of fossils is not yet forthcoming, that it is descended from primitive *Apodemus*-like ancestors. *Micromys* is characterised by numerous external and internal features which are apparently the outcome of a peculiar specialisation

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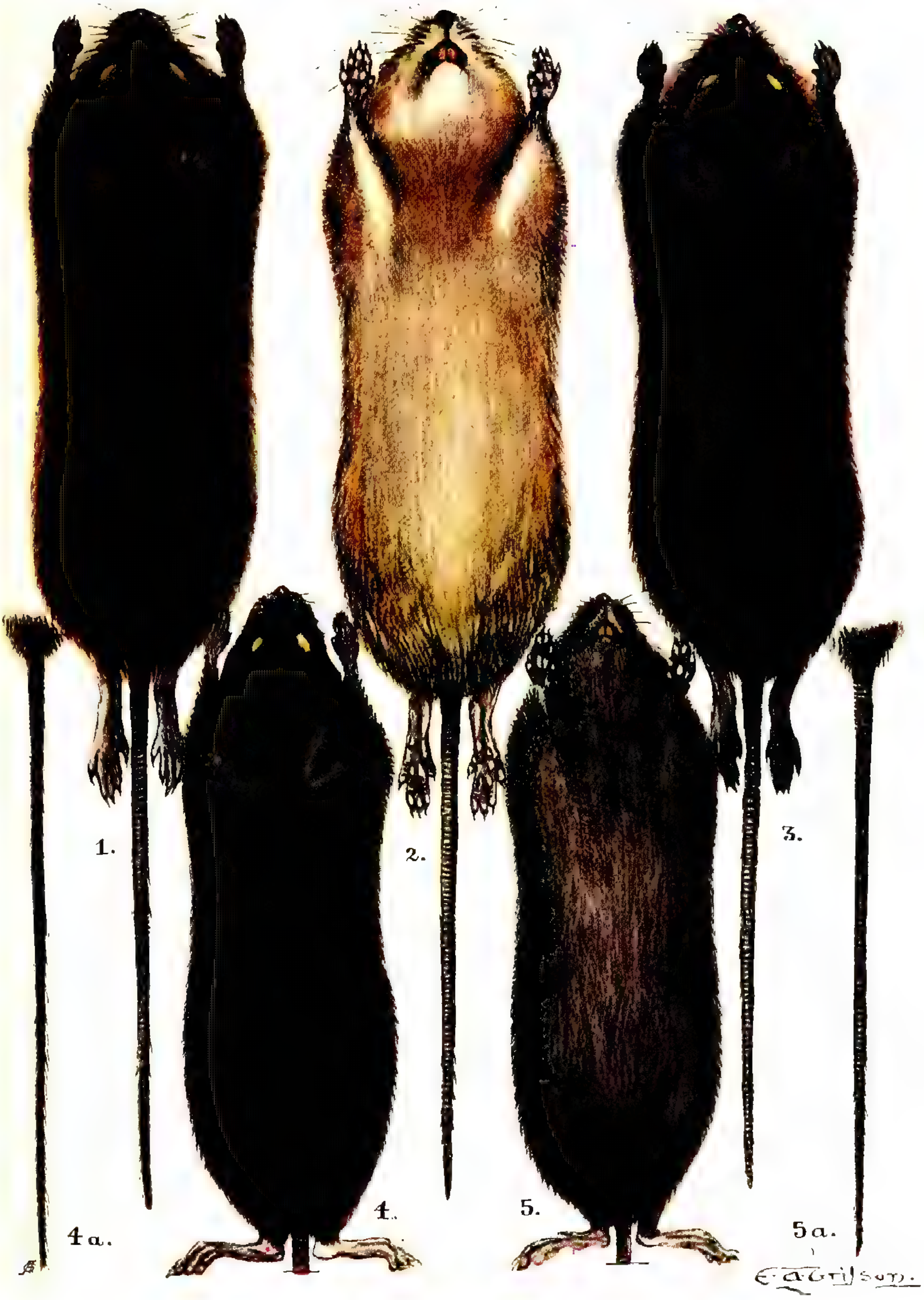
[1] Mr Adams writes:—"I sent the specimen to Barrett-Hamilton, and he sent me his opinion that it was not a case of superfœtation, but that the two small embryos had died."


1.
2.
3.
4.
5.
4a.
5a.
E. A. Wilson.

BRITISH *Muridæ* (SKINS);

(1, 2) *Epimys norvegicus*; (3) *E. norvegicus*, var. "*hibernicus*"; (4, 5) *Epimys rattus rattus*.

fitting it for a life spent largely in climbing the slender stems of grains and grasses. The size is diminutive, and the build elegant and slender; the weight of an adult is scarcely more than one-sixth of that of an adult *A. sylvaticus.*[1] The tail is prehensile (a character unique among British mammals). In the large hands and feet the pads are of large size and somewhat modified form; they serve apparently, as in many other climbing mammals, the purpose of "climbing-irons." In the ear the antitragus is developed as a large triangular valve which is capable of completely closing the meatus. The eyes are smaller and less prominent than in *Apodemus.* In the skull (as in many climbing mammals) the brain-case is relatively large; the facial region, particularly the rostral part, relatively small. The cheek-teeth are essentially like those of *Apodemus*, but cusp 5 in m^1 and m^2 (Pl. XXVIII., Fig. 7) is reduced or obsolete; in m_1 and m_2 the outer row of tubercles is reduced to a low, laterally compressed ridge or cingulum. There are eight mammæ, of which two pairs are pectoral and two pairs inguinal.

Scharff (*Hist. Eur. Fauna*, 1899, 4) thinks that the "distribution indicates that the Harvest Mouse has most likely originated in the East, and has spread from there westward in recent geological times." No fossil remains of *Micromys* have so far been detected; but the existence of the species in Japan points to its being of ancient standing in the East.[2] Among Oriental mice, the arboreal genus *Vandeleuria* presents a close resemblance to *Micromys* in skull and teeth; the hinder part of the palate is, however, simpler and more normal in structure.

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[1] See below, p. 565.

[2] We are informed by Oldfield Thomas that on examining reliable material recently he found that Blyth's *Mus erythrotis*, described from the Khasia Hills, Assam, is a species of *Micromys.*

THE HARVEST MOUSE.

MICROMYS MINUTUS, Pallas.

MICROMYS MINUTUS SORICINUS, Hermann.

1771. MUS MINUTUS, P. S. Pallas, *Reise*, 1, App., 454, described from the banks of the Volga, Russia; also *Nov. Spec. Glires*, 1778, 96, 345, pl. xxiv. B., etc.; as regards the typical form, of all subsequent writers.

1780. MUS SORICINUS, Hermann in Schreber, *Säugethiere*, iv., 661, pl. clxxxiii. B.; described from Strassburg, Germany; Gmelin.

1785. (MUS) TRITICEUS, Boddaert, *Elenchus Anim.*, i., 111; described from Hampshire, England.

1788. MUS SILVATICUS, var. *B.*, J. F. Gmelin, *Syst. Nat.*, 129; based on the "Harvest-Rat," Pennant, *Quad.*, ed. i., 302, n. 231.

1789. MUS MINIMUS, Gilbert White, *Nat. Hist. Selborne*, 43, 33, 34, 39; described from Selborne, Hampshire; *Mus minutus minimus*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 530; (*Apodemus*), Trouessart.

1792. MUS MESSORIUS, Kerr, *An. Kingdom*, 230; described from Hampshire; Shaw; Montagu; Pennant, *Brit. Zool.*, i., 121; Bingley; Turton; Fleming; Jenyns; Bell, ed. i.; Macgillivray; White, i., 58.

1794. MUS AVENARIUS, Wolf, *Versuche die Feldmaeusse zu vertilgen*, 16, 315; not seen, cited by Hermann, *Obs. Zool.*, 1804, 61.

1804. MUS PENDULINUS and MUS PARVULUS, Hermann, *Obs. Zool.*, 61; described from Strassburg, Germany.

1816. ? MUS ARVENSIS, Leach, *Syst. Cat. Spec. Indig. Mamm. and Birds, Brit. Mus.*, 7; a *nomen nudum* for "Harvest Rat" from Devonshire.

1822. MUS CAMPESTRIS, A. G. Desmarest, *Mammal.*, ii. 543; described from France; *Mus minutus campestris*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 529; described from Waremme, Liége, Belgium; (*Apodemus*) Trouessart.

1823. MUS MINUTUS, F. Boie, *Isis*, 970; described as very frequent in Schleswig and Holstein; *Mus messorius* stated to be probably a synonym of *M. minutus*, Pallas; A. Brants (1827); Oken, *Allg. Nat.*, vii. *ab.*, 2, 718.

1832. MUS MERIDIONALIS, Costa, *Fauna Reg. Nap.*, 13; described from near Naples, Italy; (*Apodemus*) Trouessart.

1841. MICROMYS AGILIS, J. F. A. Dehne, "*Micromys agilis, kleinmaus, ein neues Säugthier der Fauna von Dresden*," 1; described from Dresden, Germany; *Mus minutus agilis*, Barrett-Hamilton, *Ann. and Mag. Nat. Hist.*, June 1900, 529, from Brunswick, Germany; (*Apodemus*) Trouessart.

1841. MUS ORYZIVORUS, E. de Selys-Longchamps, *Atti d. seconda Riunione d. Sci. Italiani, Torino*, 1840, 247; described from ricefields in Lombardy.

1842. MUS PUMILUS, F. Cuvier, *Hist. Nat. de Mamm., Tabl. Gen. et Méth.*, 4; described without name (in fasc. xxxii., October 1821) from vicinity of Paris, France.

1912. MICROMYS MINUTUS SORICINUS, G. S. Miller, *Catalogue*, 844.

The **synonymy** of the Harvest Mouse of western Europe, although long, is simple. In spite of the excellent description of *Mus minutus* given by Pallas, most of the older writers hesitated to assert, though some like Shaw and Montagu suspected, the identity of the western Harvest Mouse with that of Russia and Siberia. Another cause of the multiplication of names is found in the great variability (dependent in part upon season, age, and sex, and in part, perhaps, upon the individual) of the animal itself. Boie in 1823 appears to have been the first to ascribe western specimens to *M. minutus;* his material came from Schleswig-Holstein, and he pointed out that the British *M. messorius*, Pennant, was probably a synonym. In 1827 A. Brants referred Dutch material to *M. minutus*, and although *M. messorius*, *soricinus*, and *pendulinus* figured in his book as distinct species (because specimens were lacking), he expressed his opinion as to their probable identity with *M. minutus* very clearly.

It cannot be pretended, however, that the material at our disposal is sufficient to enable us to form any very sound opinion as to the extent of the geographical variation of this species, nor even as to the status of the few sub-species at present recognised. Such material as exists is for the most part hardly mature, and there are few specimens, even of the British form, which can, from a skull point of view, be regarded as more than adolescent. Further collection may therefore very well cause certain of the names now relegated to the synonymy to be revived and used for the designation of sub-species in the future.

Terminology:—The Harvest Mouse is the *Mus minimus* of White (cited above); the "less long-tailed Field-Mouse" of Pennant (*Brit. Zool.*, 1768, ii., 498) and Berkenhout (1769). In all later works from Pennant (1776) to Millais (1905) it appears as the "Harvest Mouse," occasionally as the "Harvest Rat," so that there can be no serious question as to its correct designation, although the name is not now so appropriate as in the days of hand-reaping, when the species was much more frequently encountered at harvest-time.

Local names (non-Celtic):—*Harvest Mouse* generally; *Red Ranny* of Essex (Laver, *MS.*).

(Celtic):—Not usually distinguished. Welsh—*Llygoden yr yd* = "Corn-Mouse."

History:—The discovery of the Harvest Mouse in Britain appears to have been made independently by Gilbert White, in Hampshire, and Montagu, in Wiltshire. White, in his tenth letter to Pennant, dated 4th August 1767, alludes to a previous conversation on the subject ("which I mentioned to you in town"). Montagu (1767) has claimed (*Trans. Linn. Soc.*, vii., 274, 1803) priority for his discovery, but White's very accurate, and, for the date, complete account of the animal (Letter xii. to Pennant, 4th November 1767; xiii., 22nd January 1768; xv., 30th March 1768 ("Linnæus, perhaps, would call the species *Mus minimus*"); and lx., 2nd September 1774, and the first edition of his *Nat. Hist. Selborne*, 1789) was undoubtedly first in the field of publication. Meanwhile, in 1771 and 1778, Pallas had described the Russian form, and his name takes precedence for the species as a whole. Pennant described the animal in the 1768 edition of his *British Zoology* (ii., 498) and acknowledged White as his informant, but in subsequent editions this acknowledgment did not appear, an omission probably due, as Alfred Newton informed us, to White's own modesty, for he himself corrected the proofs of Pennant's second edition. Since that date the mouse has been well known, although rarely seen by naturalists, except those of some of the southern and eastern counties, to whom and to Bingley, who wrote an excellent account of it in 1809, science is chiefly indebted for additional details of its economy.

Distribution:—The Harvest Mouse is a widely distributed species. In Europe its range extends from Scotland and Denmark southwards to the Pyrenees, and, in Italy, to the neighbourhood of Naples; eastwards from Britain it occurs throughout central Eurasia to Japan, where it lives in southern Hondo and on the islands of Shikoku, Kiushiu, and Tsu-shima. In eastern Asia its range extends southwards from the Transbaikal and Ussuri districts to the south of China (Sze-Chuan and Fokien).

It is not known from Norway (Collett); according to Lilljeborg and Winge it is also absent from Sweden, although Blasius and Clermont mention it as occurring there; but if really present in that country, it must have a very limited distribution. It occurs in Finland; in Denmark (Winge); and is one of the most common species in Schleswig-Holstein (Boie). It is absent from the whole of Iberia (Cabrera, Scharff), and probably from the extreme south of Italy.

In **Britain** it may, according to Millais, be regarded as generally but locally distributed south of Aberdeenshire, though in Scotland it is much scarcer than in England; according to Tomes (Bell, ed. ii., 288) it is common, but somewhat local, appearing in considerable numbers in certain fields or farms, but not occurring in others, although near. Originally found by White and Montagu in Hampshire and Wiltshire, this mouse has now been recorded from most English counties. In Hampshire it is universally distributed, and it occurs also, though less commonly, on Wight (Kelsall). In the Weald of Sussex it was very abundant about fifty years ago, but has now almost disappeared with the introduction of close-cutting reaping machines (Millais)—to which cause field-naturalists generally attribute the growing scarcity of the Harvest Mouse observed in other counties. It was at one time so numerous in the wealden districts of Kent and Sussex as to commit considerable ravages in the wheat-stacks (A. Hussey, *Zoologist*, 1843, 349); in Kent it is stated to be still fairly common about Hever (Meade Waldo; also Collingwood in Millais). In Surrey, G. Dalgliesh (*Zoologist*, 1906, 188) records a pair taken in a corn-rick at Eashing, near Goldalming, and it was obtained in some number between Woking and Guildford by F. H. Salvin (Cocks). It occurs in all parts of Essex, according to Laver, and although he never met with more than a dozen in one rick, others told him of finding greater numbers; Laver (*in lit.*) says that the distribution in this county is extraordinary, since these mice are much more rare to the east of Colchester than to the west; it was frequent until about 1900. Several nests were taken in 1883, near Woodbridge, in Suffolk (E. C. Moor, *Zoologist*, 1884, 190), and Rope described it as not uncommon about Leiston (*Zoologist*, 1873, 3610). In Norfolk it was "somewhat local, but not uncommon" (Southwell, *Journ. cit.*, 1871, 2756); Southwell described it as still common in 1901; and Oxley Grabham (*in lit.*) "used to get considerable numbers from Haddiscoe." In Hertfordshire it is recorded by Bond (in Harting; see also *Vic. Co. Hist.*), although not found by Lydekker in the vicinity of Harpenden. In Cambridgeshire it was often seen by T. Bell's father, probably about 1784, and described to Bell as a third species of Field Mouse (Bell, *ipse*); from this county it is recorded by Jenyns (*Man. Brit. Vert.*, 31),[1] and also by Bartlett, who described it as occurring here, and commonly in Kent (*Zoologist*, 1843, 289); no recent records were known to Bonhote. From Nottinghamshire some mice and a nest were seen many years ago by W. Rigby of the Natural History Museum (J. W. Carr, *Vic. Co. Hist.*). In Northamptonshire it occurs, though not abundantly (Lord Lilford, *in lit.*); in Leicestershire and Rutland M. Browne describes it as rare. According to Tomes, it occurs in the southern and western, but not in the northern districts of Warwickshire[2]; it was obtained in Oxfordshire by Rolleston (A. H. Cocks). In Bedfordshire it was not uncommon, about 1830, at Benham, although not met with in recent times by Steele Elliot. Cocks has no knowledge of it in Bucks. In Worcestershire it was formerly more abundant in the valley of the Avon, according to Tomes, who often saw the nests. In Shropshire four or five nests were taken in August or September 1872, at Church Stretton, twelve miles from Shrewsbury (G. W. Murdoch, *Zoologist*, 1895, 447); Forrest states it to be very local in this county; he mentions a pair and nest in T. C. Eyton's collection from Weald Moors (70/71). Miss Pitt (*in lit.*) states that it is certainly not to be found anywhere near Bridgnorth. It is recorded from Staffordshire by Garner and Masefield, and Gloucestershire by Knapp and Mitchell (in Harting). From Devonshire it is recorded by Montagu, Rowe (who states it to be not common), Bellamy, Parfitt (in Millais), and Donovan (who had a specimen). In Cornwall one was caught by E. H. Rodd, 20th February (*Zoologist*, 1857, 5592); it was stated by Couch, i., 3, to be common, and was well known to C. W. Peach (*ibid.*, 5664); J. Clark (*Zoologist*, 1908, 416) describes it as very common locally about Penzance, Falmouth, and in the middle of the county, but as scarce or very local on the north coast. In Somerset, Charbonnier describes it as local, decidedly scarce in the winter, but fairly common a few miles from Yeovil; in the Bristol district it is rare and local. From North Wales, Forrest has no certain record, but he has received reports from Carnarvonshire and other localities (*North Wales*, 49); Phillips describes it as very rare indeed in Brecon, and Coward makes no mention of it in his list (*in lit.*) from Anglesey. It is sparingly present in Lancashire and Cheshire, according to T. A. Coward, who mentions (*Zoologist*, 1895, 175; 1896, 16) a nest from Southport in the Museum of Owens College, Manchester, 1864; in the former county many were found by the reapers near Garstang, in September 1843, and sometimes the nest and young were accidentally bound up in the sheaves without discovery or injury (M. Saul, *Zoologist*, 1843, 349); in the latter county it is now very rare, and has not been noticed in recent years (Coward). In the Lake District it is so rare that Macpherson knew of only two instances, namely, a nest taken many years ago at Blackwell, and a specimen captured at Silloth by J. H. Doeg in 1888; Macpherson (*Vic. Co. Hist.*) describes it as rare in Cumberland, but mentions specimens captured in isolated instances in the north. There is a vague record of it from Derbyshire (Jourdain). In Yorkshire it is very irregularly and thinly distributed (Clarke and Roebuck; copied by later writers); in Nidderdale, George Charlton said he saw it nesting in a cornfield—but no specimens were seen by authors; and Oxley Grabham (*in lit.*) writes that though he will not "go so far as to say it never has been taken in the county, the few records are so unsatisfactory that he holds it non-proven at present." J. T. Sewell (*in lit.*) claims to have found the nest near Helmsley, Yorkshire. It is recorded from a few localities in Northumberland and Durham (Mennell and Perkins, 1864, 171); it was taken by William Backhouse, at St John's, Weardale, 800 feet above the sea (*Trans. Tyneside Nat. Field Club*, iv., 94; for Durham, see also *Vic. Co. Hist.*).

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[1] Jenyns, *Obs. Nat. Hist.*, 73, says Harvest Mice "are common in Cambridgeshire."

[2] "About thirty years ago the late A. B. Herbert, Edinburgh, obtained a number from Warwickshire, and kept them for a year or two in a large cage made for their reception, where I have often enjoyed watching them exercising on the wheels and other contrivances for their amusement" (W. Evans, *MS.*).

The species thus seems to be much rarer in the north of England than in the south. It undoubtedly has occurred and probably still occurs in Scotland, but it must be very local and cannot be anywhere numerous; as in the case of much of England, it would appear to have decreased or to be less often met with than formerly. Very sporadic records are all that could be collected for the Edinburgh district (1836-1905) by W. Evans, who however, himself found an unmistakable nest in August 1885, near Aberlady, East Lothian. Neither Harvie-Brown nor Millais (177) have met with the species in Scotland, and the former thinks that many records could be dispensed with. W. Evans states (*in lit.*) that he can obtain no fresh information from Scotland, and that he has quite failed to procure or see a specimen; he thinks the species may not really be indigenous, but occasionally establishes itself in a locality for a time. Prof. Duns found a nest near Duns, Berwickshire, before 1844; and Small (taxidermist, Edinburgh) informed W. Evans that about 1861 he received three, he believes from near the same town. Service (*Ann. Scott. Nat. Hist.*, 1896, 205) says that although he had seen and handled the mice and nests from corn-stalks on Rotchell Farm, near Maxwelltown, it has nowhere been seen or heard of in the Solway district for over twenty-five years. In Ayrshire it seems to have been common about 1855, and was seen by G. W. Murdoch (*op. cit.*). J. M. B. Taylor (*Ann. Scott. Nat. Hist.*, 1898, 112) mentions a nest found in 1895, at Kilbarchan, Renfrewshire, now in Paisley Museum, and states that he has seen other nests in the county. A doubtful specimen in the Andersonian Collection (Hunterian Museum) from the Clyde district is mentioned by Boyd Watt. In Perthshire, Millais believes it may occur in the Carse of Gowrie. It is mentioned in a list of animals from Alloa (*New Stat. Account, Clackmannanshire*, 9), in which also its size and weight are correctly noted; and the eastern distribution in Scotland of this comparatively southern form as compared with that of birds is discussed by Gray and Anderson (*Birds of Wigtownshire*, 4; E. R. Alston). One from Kincardineshire, caught in 1869, is recorded by R. Gray (E. R. Alston). It is not known in the Llanbryde district, according to Taylor. Macgillivray had two specimens, one sent from Aberdeenshire, the other from near Edinburgh, and he once found the nest in Fifeshire. Sim heard of one taken in 1889 at Kennay House, Banff, by Stewart Burnett (*Ann. Scott. Nat. Hist.*, 1898, 46); he also mentions one in Banff Museum, said to have been taken at Greenskairs, Gardenstown. This is in part confirmed by T. Edward (*Zoologist*, 1861, 7379), who received two from Wallas Gardiner, Greenskairs, Gamrie, Banffshire; Edward sent one of these, said to have been 4 inches long, including tail, and to have weighed $\frac{1}{8}$ ounce 13 grains, *i.e.* 4·38 grammes, or a little less than the weight recorded by Gilbert White (see p. 565) to the Banff Museum. W. Taylor (*Ann. Scott. Nat. Hist.*, 1897, 249) says there is no Harvest Mouse in Banff Museum, and he thinks Edward probably mistook young bright-coloured Field Mice for Harvest Mice (see also W. Evans, *Ann. Scott. Nat. Hist.*, 1898, 47).[1]

According to E. R. Alston (*MS.*, in his copy of Bell), the Harvest Mouse is generally but locally distributed in the eastern lowland counties of Scotland, but it is absent from the west and north of Scotland.

The Harvest Mouse does not occur in **Ireland**, although it has been recorded thence in error on several occasions. Thus Bell's record (ed. ii., 291, *fide* Kinahan) has been shown by A. G. More[2] to be an error. A nest of young mice found in a thistle in a field of oats in Co. Donegal (S. A. Brenan, *Irish Nat.*, 1898, 125) may have been that of the Lesser Shrew (Scharff, *loc. cit.*). Thompson (iv., 1856, 15) also has a note from Shane's Castle Park, Co. Antrim, of a nest described as suspended between stalks of wheat, but this could not have been the nest of a Harvest Mouse.

Distribution in time, and origin:—The species is quite unknown as a fossil; its absence from Ireland, and its present absence from much of England and Scotland, together with its wide distribution in the East, indicate that it is an Eastern species which has arrived in western Europe only at a comparatively recent date.

Description:—The Harvest Mouse is characterised by its exceedingly small size, elongated and slender form, and by its bright coloration. The head is narrow, the snout short and blunt. The eyes are black, quite small, and less prominent than in the Field Mouse. The ears are relatively small, rounded and thick; they extend barely half-way to the eyes when laid forwards: in each the antitragus is developed as a triangular valve about 2 mm. high, capable of completely closing the meatus; this valve is clothed with a tuft of long hairs, nearly 5 mm. in length, and the general surface of the ear, both within and without, is clothed with shorter and finer hairs. In the **hands** the pads are arranged as in the Field Mouse, but the posterior two are relatively larger, closely approximated or even fusing together along the median line behind, and forming with the small thumb a single tubercular mass opposed to the balls of the fingers; in addition, a small free pad is present external to that at the base of the fifth finger (Winge). The **feet** are long and narrow (though relatively a little broader than in the Field Mouse); the soles are naked; the pads are like those of *A. sylvaticus* in number and arrangement, but the two posterior ones are relatively larger and of more elongated form, the sixth being more than twice as long as wide. The **tail** is about equal to the head and body in length; it is thinly clothed with short hairs below, and still more sparsely above, the terminal portion of the upper surface being bare; there is no true pencil, though an inconspicuous tuft usually projects beyond the under-side of the tip; it has about 130 scaly rings which are more distinct below than above throughout, and on the dorsal surface of the prehensile terminal portion these rings are completely broken up. The tip of the tail for about three-quarters of an inch is distinctly prehensile, having the power of twisting on itself for about two turns, the upper portion being also capable of a half turn. The tip instinctively curls round and grasps anything that it touches, and thus affords a sense of security to its owner, but it cannot be used like a monkey's tail, to support the mouse's body or to swing by. It is thus slightly more differentiated than the tail of the Dormouse, which simply tends to twine round anything it may touch, and is far more advanced as a fifth hand, and in a slightly different manner, than the tail of a true mouse or rat, the function of which is balancing or sometimes delaying. The glands of Tyson are well developed (de l'Isle, 181).

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[1] Edward's description appears to leave little room for doubting that his specimens were really Harvest Mice; Taylor's suggestion does not seem probable, inasmuch as young Field Mice of the size indicated would be in the dull juvenal pelage (see the table at p. 515 above).

[2] In J. E. Harting, *Zoologist*, 1895, 420.

Pelage:—The soft fur is comparatively thick and bristling. The hairs of the upper parts have slaty bases and bright-coloured tips, while those of the belly are white throughout for the most part, although some of them may have slaty bases also. The longer hairs of the back show but a slight tendency to assume the form of bristles. Winter specimens have the upper parts of an almost uniform reddish-brown **colour**, approaching but rather brighter than the "tawny" of Ridgway; although the tint on the sides of the neck and on the head is occasionally less bright than on the back, the difference is never great enough to produce any marked contrast. On the flanks and the outer surfaces of the legs the colour becomes gradually paler, fading towards ochraceous buff; the darker colour of the back is due in part to the black-tipped hairs with which it is inconspicuously sprinkled. The ears are lighter than the back, approximately matching the sides in colour. The under parts of the body and limbs are dull white. The line of demarcation along each side is regular and well defined, although (in a close view) the contrast between the lower flank colour and that of the belly is not a particularly striking one. The feet are of a pale yellowish-brown colour. The tail is obscurely bicoloured, the hairs of the dorsal surface being a light yellowish-brown, while those of the ventral surface are a little paler, the skin being light brown below and dusky above. According to Blasius, the winter colour is less pure red and more mixed with grey than is that of the summer pelage. Miller describes summer specimens from Germany (compared with winter skins from England and Switzerland) as having the upper parts noticeably darker and duller than in winter, approaching the russet of Ridgway, but with a tinge of rufous ; the sides dull cinnamon, the under parts dull ochraceous buff, the median line having, however, especially about the chin and throat, traces of white in the form of ill-defined lines and blotches; the line of demarcation inconspicuous, the feet and tail as in winter, but more thinly haired, and therefore more obscurely coloured. It is quite likely that were more mature material than that upon which these descriptions are based available, rather more vivid hues would be found to characterise both winter and summer coats than those indicated here.

Rope (*op. cit.*, 1884, 59) says that in the adults examined by him the bright sandy yellow or orange fawn of the upper side was purest and brightest towards the tail, on the hindquarters, and downwards towards the vent; this bright but delicate tint shaded off gradually into the yellowish or orange brown of the upper parts generally, which latter hue became brighter and lighter towards the white under-side. A large male lacked the orange tint altogether, the upper parts being nearly uniform brown, as in very old Brown Rats. Another male had the mid-dorsum dark red-brown, inclining to purple, owing to the unusual quantity of the long coarse dark hairs present.

Sexual differences:—According to Darwin, the female of *Mus minutus* is of a paler and dirtier tint than the male[1]; Rope (*Zoologist*, 1884, 59), however, fancies "the brilliant fawn tint" is most pronounced, as a rule, in females.

The **young** are duller coloured, more like House Mice in appearance than the adults. Harting (*Zoologist*, 1895, 421) observed some young, from Sussex, born in captivity; these, even when almost as large as the old ones, were not nearly so red. Indeed, until the beginning of December they resembled a House Mouse in colour. About that time, however, they began to change visibly, the hindquarters, from the root of the tail upwards, becoming rufous before any other portion of the body. Two young with Millais (174) began to assume the adult pelage in January.

Variation:—Tomes (in Bell, ii., 292) records the following variations—one from Warwickshire had the whole upper side of a dirty sulphur-yellow, the under parts as usual. One kept in confinement for a considerable time and fed on hemp seed became eventually "very much mottled with dark brown on the back"; it was then fed for several months exclusively on hemp-seed, but no further change took place. Perhaps speaking of the same case, Tomes mentions elsewhere (*Worcestershire*) one, which fed on hemp-seed, "changed from the usual yellow to a deep red chestnut colour."

Skull and teeth:—Apart from its small size, the delicate skull of the Harvest Mouse is characterised by the great development of the cerebral, and the corresponding shortening of the facial regions. The smooth, ovate, evenly inflated brain-case nearly equals, and in Far Eastern sub-species occasionally exceeds, the zygomatic breadth in width. The parietal region is well vaulted; the edges of the short inter-orbital region are quite sharp, though not ridged. The anterior edge of the masseteric plate is straight, not curving forwards, and it scarcely projects beyond the front edge of the slender roof of the infra-orbital canal. The nasals fuse with each other at an early stage of growth; they are short and rather narrow; the processes of the premaxillæ supporting them in front are but weakly developed. The diastemata are short, the anterior palatal foramina are relatively about as in *A. flavicollis.* Notwithstanding the shortness of the rostrum, the palatal length is about as great relatively as in *A. sylvaticus;* this is due to the greater development of the posterior palatal shelf, which in this genus has a structure very similar to that of *Microtus* (*cf.* Fig. 89 with Fig 73D. above, p. 459). Posterior lateral bridges and fossæ, and a posterior median septum, the ventral surface of which is frequently slightly grooved, can all be distinguished just as in *Microtus*, but these parts, in correlation with the brachyodont teeth, are, of course, sculptured in lower relief in *Micromys*, and they are situated behind, instead of between, the tooth-rows. The inter-pterygoid space begins about 1 mm. behind the tooth-rows, and is narrower in front than behind. The basi-occipital is compressed slightly, its anterior width being less than its median length, and the median ridge and lateral furrows of its ventral surface are well defined. The bullæ are of large size and rounded form. The following *proportional* measurements (condylo-basal length = 100), obtained from a series of skulls representing nearly all known sub-species of *M. minutus*, may be compared instructively with those of *Apodemus* given in the tables at pp. 519 and 539 above:—(5) Cranial width, 51·7 to 57·8; (6) cranial depth, 30·9 to 36·6; (7) post-molar length, 48 to 50·9; (8) condyle to

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[1] *The Descent of Man*, ed. ii. (25th 1000, 1889), 534.

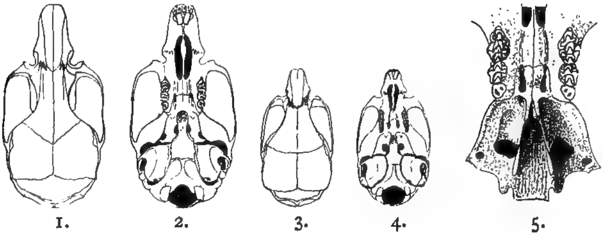

FIG. 89.—SKULLS OF *Apodemus* and *Micromys.*
Apodemus sylvaticus, (1) dorsal, (2) ventral view; *Micromys minutus*, (3) dorsal, (4) ventral view. (1-4 life size.) (5) Palate of *Micromys* (3 times life size).

bulla, 31·5 to 34·4; (9) and (10) nasal length and breadth, 29·2 to 36 and 8·6 to 11·5; (11) palatal length, 50·9 to 54·3; (12) diastemata, 22·1 to 25·2; (13) incisive foramina, length, 17·6 to 20·6. The dimensions not mentioned here are in substantial agreement with those of the Field Mice.

The mandible is much like that of the Field Mouse in form, differing, apart from its much smaller size, only in some slight details of the angular and coronoid processes, the former being a little more concave above, the latter a little more recurved. The **cheek-teeth** (Pl. XXVIII., Fig. 7) are described above under the genus.

Geographical variation:—In addition to *M. m. soricinus* and *minutus* (of which last no specimens have been seen), five or six other sub-species are at present recognised. Of these, *M. m. pratensis*, Ockshay (*Nov. Act. Phys.-Med. Acad. Caes. Leop. Car. Nat. Cur.*, xv., 2, 1831, 243, described from Western Hungary), ranges throughout Hungary into Rumania. In this form, as described by Miller, the posterior half of the body and the outer surfaces of the hind legs are as in *soricinus*, the head and the anterior half of the body are decidedly greyish, the white under parts receive a bluish tinge from the slaty hair-bases, and the tail is rather sharply bicoloured. In a series collected at Csehtelek, Eastern Hungary, during October and November 1913, by Fräulein von Wertheimstein, specimens with unworn or very slightly worn teeth (condylo-basal length from 15·6 to 16·5 mm.) have the coloration as in *pratensis*, the rufous tint so characteristic of similarly grown British Harvest Mice only appearing towards the rump; in a female with slightly worn teeth (head and body, 63; condylo-basal length, 16·9 mm.) the colour, save for slightly darker flanks, is nearly as bright and rufous as in specimens taken at Colchester in April; in a fully adult female with half-worn teeth (head and body, 71; condylo-basal length, 17·8 mm., B.M. No. 14.1.3.35) the colour is quite as red and bright on the head, back, and flanks as in the brightest English specimens; the hairs of the belly and chest are pure white to their bases, and on each side between the white belly and the rufous flanks there is a narrow belt of almost pure buff.

The remaining sub-species are Asiatic. *M. m. batarovi*, Kastchenko (*Ann. Mus. Zool. Acad. Imp. Sci., St Petersburg*, xv., 1910, 284), from the Transbaikal, is characterised by its short tail, measuring only from 60 to 70 per cent. of the length of the head and body; by its dark back, rufous towards the rump, and its ashy-white belly. *Mus minutus*, var. *kytmanovi*, Kastchenko (*op. cit.*), is described as an intermediate between typical *minutus* and *batarovi*. *M. m. ussuricus*, Barrett-Hamilton (*Ann. and Mag. Nat. Hist.*, April 1899, 344), described from Ussuri, Eastern Siberia, is a dark-backed form with the belly washed with dirty yellow, and no distinct line of demarcation. *M. m. pygmæus*, Milne Edwards (*Rech. Mamm.*, 291, 1874), is a dark-coloured, rather long-tailed form inhabiting Southern China. *M. m. japonicus*, Thomas (*P.Z.S.*, 1905, 351, described from Shikoku), inhabiting Japan, is a dark-backed mouse with rufous rump and sharply contrasted white belly, the hairs of which have slaty bases; one old specimen, however, is more or less rufous over the whole of the upper surface (Thomas); the skull has an unusually large brain-case, and the cheek-teeth are decidedly larger than those of *ussuricus*.

It would appear that all forms of *M. minutus* have, at one stage of growth, dark backs, the rumps only being then rufous; that in the Western *soricinus* the change to the rufous coat of maturity is made quickly, and that some of the Eastern races, such as *pratensis* and *japonicus*, may acquire, at all events occasionally, such a rufous coat as old age advances.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear.
Average of 8 young in nest, fur just appearing (L. E. Adams)	27	21	8	..
MALES:—				
In rufous pelage:—				
Sussex (L. E. Adams), 3rd Sept. 1909 .	57	59	14	..
Essex, Colchester (Dr H. Laver)—				
24th April 1903	55	55	14	8
Do.	57	55	14	9
Do.	58·5	54	14·5	9
Norfolk, Congham (Oxley Grabham)—				
26th Dec. 1898	64	61	15	9
Do.	65	58	14	8
Norfolk, Haddiscoe (L. C. Farman)—				
24th Dec. 1898	58	52	14	9
Do.	59	58	14	8
Do.	59	56	15	8
1st Feb. 1899	59	57	15	8
FEMALES:—				
Essex, Colchester—(Dr H. Laver)—				
24th April 1908	57	53	14·5	8·5
Do.	58	58	14	8
Norfolk, Haddiscoe (L. C. Farman)—				
24th Dec. 1898	56	52	13	8

Remarks:—White (Letter xiii., 22nd Jan. 1768, to Pennant) found that his specimens from nose to tail were just 2¼ inches, and their tails just 2 inches long. Rope (*Zoologist*, 1884, 59) gives the average total length of seven adults as 4 inches 8½ lines: the head and body averaging 2 inches 7½ lines, the tail 2 inches 1 line.

Weight:—White (Letter xiii.) says: "Two of them, in a scale, weighed down just one copper halfpenny, which is about the third of an ounce avoirdupois. . . . A full-grown *mus medius domesticus* [i.e. *sylvaticus*[1]], weighs, I find, one ounce lumping weight, which is more than six times as much." The weight thus indicated by White equals about 4·7 grammes. The weights recorded by other observers are:—Edward, Banff (see p. 559), ⅛ ounce, 13 grains = 4·38 grammes; "an old one"[2] is said to have weighed 1 drachm, 5 grains = 2·09 grammes; another[3] "scarcely exceeds a drachm," or 1·77 grammes. The two last examples were probably immature nestlings, and the others can hardly have been fully mature, because Owen (*Anat. of Vertebrates*, iii., 143) gives the weight of a specimen which he dissected as 112 grains, or about 7·25 grammes. In this individual the brain weighed 6 grains, or nearly ·39 gramme; in a House Mouse weighing 327 grains, or nearly 21·2 grammes, the brain weighed no more.

Skull:—Condylo-basal length, 16 to 17·8; zygomatic breadth, 9 to 9·6; inter-orbital constriction, 3 to 3·2; brain-case, breadth, 8·6 to 9·6, depth at middle, 5·2 to 6·2; length of nasals, 5·4 to 6; of diastema, 3·9 to 4·6; of mandible, 9 to 10; of maxillary tooth-row, 2·6 to 3; of mandibular tooth-row, 2·6 to 2·8 mm.

Distinguishing characters:—The Harvest Mouse is readily distinguishable among British murines by its small size, bright reddish dorsal tints, and sharply contrasted white belly; its blunt short nose (somewhat recalling that of a young Bank Mouse); and by the characters of the ears, hands, feet and prehensile tail, as described above.

The Harvest Mouse presents us with many points of interest. Not only is it one of the prettiest and smallest of British mammals, but it is a highly specialised mammal, fitted by its structure for life amongst beds of strong grass, reeds, or corn, and living on a diet of seeds and insects. It is, consequently, a very acrobatic creature, light enough to poise itself on a head of corn, and a nimble climber amongst the stalks. It is a fine gymnast; at times it revolves[4] vertically, horizontally, or at an angle, balancing itself or helping a descent with its slightly prehensile tail[5]; but it is not as fast and active as the House Mouse, nor a grand jumper like the Field Mouse, and hence it is more easily caught by hand. It is fond of frequenting tall, rank herbage growing by the sides of ditches,[1] especially such as have a little run of water through them.[2] Mr E. G. B. Meade-Waldo (*in lit.*) describes it as loving hedgerows fringed with brambles, grass, and weeds. In early spring he can always find it, before the herbage gets strong, running on certain banks in and out of holes, and along low branches; in August he sees it climbing about the grass and weeds. Unlike the Field Mouse, it is in the main diurnal, and in captivity it is aroused to activity by light. In summer it shelters itself during sleep, and rears its young, in a wonderful little round nest of plaited grass blades suspended so neatly amongst living plants as to have long excited the admiration of writers.

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[1] Or more probably in this case *A. f. wintoni*; for White gives the lengths of head and body and tail as 4¼ inches (108 mm.) each, the weight mentioned being nearly 29 grammes.

[2] Knapp, *Journal of a Naturalist*, 139; cited in *Zoologist*, 1843, 292.

[3] W. Hewett, *Zoologist*, 1843, 349.

[4] D. English, *Some Smaller British Mammals* (undated), 81.

[5] G. T. Rope, *op. cit.*, 1884, 58, has repeatedly seen one supporting the weight of its body on the tail for a second or so in trying to climb out of an upright glass jar, the fore paws merely balancing the animal's weight against the glass. Millais has seen them hang free by the tail, but it cannot swing or hang thus for any length of time.

In winter, according to Gilbert White, it burrows deep in the ground, making there a warm nest of grass, in which it is supposed to hibernate.[3] But in corn-growing districts, where common, it seems to find all its wants more easily. Here it is satisfied by the corn-stacks,[4] where it shares its quarters with the House Mouse until threshing time, and exhibits no sign of torpidity. It prefers ricks of oats and wheat to those of barley,[5] and the lower parts of the stacks, or the rubbish on which they are built, to the upper parts[6]; after thrashing, it may remain on in the straw.[7] Sometimes large numbers, but not usually so many as of the House Mouse, are killed when a rick is thrashed[1]; and White (Letter lx.) made the observation that on one occasion the dogs devoured the Harvest, but rejected the Common Mice; the cats, *vice versâ*. Blasius describes it as not rarely entering houses in autumn; this is not unlikely in the colder portions of Central Europe, although such a habit does not appear to have been observed in Britain.

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[1] G. T. Rope, *Zoologist*, 1880, 57.

[2] Dr H. Laver (*in lit.*).

[3] "All mice and voles sleep fitfully during the winter, hardly ever moving if the temperature falls below freezing-point, becoming active again in search of food when milder weather returns. To this rule the Harvest Mouse is no exception. Mr Thorburn caught one running in a hedgerow close to his house at Hascombe, Surrey, in December 1904" (Millais, ii., 182). Mr Meade-Waldo (*in lit.*) has never seen it in winter, except with the House Mouse in stacks.

[4] Either carried in the sheaves or finding its way there naturally. Though preferring corn-stacks it will also sometimes occupy hayricks (H. Laver, *MS.*), or straw (Millais).

[5] Perhaps because barley is too rich and indigestible, but English states that captives "are quite indifferent as to what kind of grain they eat"; and Patterson, East Norfolk, 1905, 315, mentions many found in the bottoms of barley-stacks.

[6] Gilbert White (Letter xiii.), however, mentions nearly a hundred under the thatch of an oatrick; see also H. Laver, *Field*, 14th April 1883, 499. The mice probably retire from the upper towards the lower parts as the dismantling of the rick progresses.

[7] H. Laver, *op. cit.*; G. T. Rope, *Zoologist*, 1884, 56, but whether it breeds in stacks or barns, as thought to do by Bell (ed. ii., 287), is uncertain.

The late Professor Schlegel[2] was so fortunate as to find the winter nests of the Harvest Mouse in a wide ditch near Leyden, Holland. These, composed of moss, were attached to and between the stems of several reeds, and resembled, though more fusiform, the nests of the Reed-warbler. Their height was from 6 to 12 inches, their breadth 3 to 4 inches; they hung about a foot over the water, without visible means of ingress, so that when entering a mouse had to find its way through the comparatively loose upper portion. In some cases the deserted nests of Aquatic Warblers had been adapted by provision of a cap of grass. The colony consisted of about fifty nests, and in summer these were replaced by the usual globular structures, of the average size of a man's fist, and with a small circular opening near the top.

The summer nests always contain a bed of soft shredded grass. They are placed in coarse, rank herbage; in low bushes in open country; but preferably near or on growing corn-stalks. The nest described by White (Letter xii.) "was found in a wheatfield, suspended in the head of a thistle"; that found by Macgillivray in Fifeshire was in the midst of a tuft of *Aira cœspitosa*, and about 9 inches from the ground; Blasius found nests in grass near a pond, and once saw "thousands" of the mice climbing and hanging on grass stalks over flooded ground; Schlegel found nests in *Rubus fruticosus*, *Rumex acetosa*, *Epilobium*, and in Purging Buckthorn[3] on sand-dunes in Holland. Other nests have been recorded in the boughs of a wild Clematis[4]; in long grass near the hedges of stubbles in Kent and Sussex[1]; in tall sedges by the river Waveney at Gillingham, Norfolk; and in Marram-Grass on the sea-beach, almost within reach of the spray, at Kessingland, Norfolk[2]; in straggling Blackthorns beside a ditch (on 30th November); and in a plant of common Broom[3]; upon "laid" barley in Suffolk (several, almost all containing young)[4]; affixed to stems of *Centaurea nigra*[5]; 18 inches from the ground, supported by stems of grass and a few twigs of a hedge surrounding a cornfield, East Lothian[6]; and lastly, one on the ground amongst grass and clover.[7]

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[1] Landois, *Zool. Garten*, 1871, 163.

[2] *Notes from the Leyden Museum*, iii., 23-28, 1881; reprinted in *Zoologist*, 1881, 233-37.

[3] *Hippophae rhamnoides*.

[4] W. Hewett, *Zoologist*, 1843, 349.

In this country, unlike the nests described by Schlegel (above), the summer nest, which is globular and of about the size of a cricket ball, has no regular aperture for entrance, though the place where the mice find their way in and out through the side or top is sometimes noticeable.[8] The body of the nest consists of leaves split into short lengths, which naturally contract, shrivel, and become confused together to form a bed. Mr D. English found 250 split lengths in a single nest, and calculated that at least 100 complete leaves had been utilised. When built in corn or reeds, the stalks are used as piles; the leaves growing from these piles are left attached to their stalks, although they are sometimes first split into narrow bands[9]; these leaves are interwoven so as to form the sides or foundation of the nest. Such nests, though no doubt compact enough when in their natural position, are difficult to handle when removed, for owing to their loose cohesion they easily lose their shape and swell in size. Nests built in less convenient or more precarious situations are stronger, and will suffer considerable violence without injury on removal; thus White's nest, from a thistle head, "was so compact and well filled, that it would roll across the table without being discomposed, though it contained eight" young. The nests are probably put together rapidly, and their precarious situation amongst quickly growing herbage implies frequent change and reconstruction of domicile. Millais suggests that the nests are now more seldom found in standing corn than formerly; that, since it breeds several times during the season, there are several nests, the first among wild vegetation, another [or two] amongst corn, and a third or fourth amongst corn-ricks.[1]

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[1] A. Hussey, *loc. cit.*

[2] Crowfoot in Southwell, *Zoologist*, 1871, 2756.

[3] G. T. Rope, *Zoologist*, 1880, 57.

[4] E. C. Moor, *ibid.*, 1884, 190.

[5] Newstead, *Proc. Chester Soc. Nat. Sci.*, iv., 248.

[6] W. Evans.

[7] L. E. Adams (*in lit.*)

[8] They probably show entrance-holes when old; witness one with three apertures inhabited by eight nearly full-grown mice (W. Hewett, *Zoologist*, 1843, 349).

[9] Gloger in White's *Selborne*, by Bennett, 58, *note;* cited by Tomes in Bell, ed. ii., 290.

Mr A. H. Waters enjoyed several opportunities for watching the Harvest Mice at work in a cornfield in Cambridgeshire. From his MS.[2] it would appear that the doe gathers the materials for the nest. She sits up at the base of the plants forming the chosen site, and holding a "leaf with her paws while biting the edge with her teeth, she tears off a long strip. Then holding one end of the strip with her teeth, she goes through a variety of movements so rapid that it is impossible to follow them, but the result is a tangle of the whole slender ribbon of leaf. . . . Next, after a run up and down the stems of the wheat or thistle, she proceeds to tug the tangle up to the summit. Sometimes. . . . she pushes it up, or carries it as well as she can in her teeth. Having got it up, she rests it where it will stop supported by the cornstalks or the branches and leaves of the thistle. . . . Now she splits the leaves of the wheat-stalk much as she did the detached leaf she selected for the foundation of her nest, but this time the strips are only half torn from the leaf. These strips she weaves in and out the tangled strip she carried up the stalk. The result is that the half-completed nest is securely fastened to three or four stalks and is free to wave in the wind" without risk. "Individual mice vary in their way of finishing the nest. Some do little more to it except making the bed inside the woven cradle. Others add more strips of leaf, and make a fairly compact structure. Some carry up grass stems and interlace them with the rest, and also take up leaves and even feathers and scraps of wool. . . . I do not know whether it is universally the case that the buck assists the doe Harvest Mouse in the task of nest-making. But it does sometimes, and it is a pretty sight to see the two working together. Although the shyest of rodents, they do not seem to notice the observer if he remains perfectly still and carefully refrains from making any noise."

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[1] For another description and figure of nest, see Landois, *Zool. Garten*, 1871, 162; he describes neighbouring grass-stalks as being bound to the nest to serve as ladders for the young.

[2] In chapter xx. of an unpublished MS., entitled *The World of Animal Thought*, by A. H. Waters, B.A. (quoted from an extract found among Barrett-Hamilton's papers; I have not been able to find out where the MS. itself reposes.—M. A. C. H.).

The nest of the Harvest Mouse is built for the special purpose of providing a safe and convenient nursery for the young. From White's day onwards much has been written about the young completely filling the nest, and consequent inability of the dam to sleep in it with her babies. White suggested that the dam had to open a different place in the periphery of the nest in order to suckle each of the young; while Johnston thought that they might even be suckled outside the nest. English says, however, that the babies get proportionately as much space as would young House Mice.

Mr Rope (*op. cit.*, 1884, 58) remarks on the superior architectural skill of this mouse, which can arrange its bedding in a square box in a round, compact nest resembling the spring and summer nurseries.

The Harvest Mouse appears to be, at least in summer, not less prolific than other murines, giving birth to several litters in each season.[1] The number in a litter appears to vary between five and nine, and gestation[2] is believed to last twenty-one days. The young are born naked and blind, and they attain the adult stature in six weeks.[3] Dr H. Laver has never met with the young in cornricks, "although they are said to breed there"; he considers the breeding season to be confined to the summer months.

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[1] The following are the principal observations on the number of young in a litter:—Nine recorded by Pallas; in a nest in Brittany (E. D. Cumming); in Lancashire, M. Saul, *Zoologist*, 1843, 349; and by Gloger in Bell, ed. ii., 290. Eight by White (Letter xii.); Bingley, 267 (September 1804); in nest, Sussex, L. E. Adams (*in lit.*). Seven on three occasions, D. English (*op. cit.*, 83). Six to eight several times in Suffolk, Moor, *Zoologist*, 1884, 190. Six or seven naked and blind in nest, Macgillivray. Six in a nest lined with roots and fibres, not so compact as White's nest, but round as in his description, Jenyns, *Obs. Nat. Hist.*, 73, 29th July 1826. Five, Gloger in Bell, ed. ii., 290. G. W. Murdoch found two young but full-grown mice in a nest and three empty nests, in Shropshire in 1872 (*Zoologist*, 1895, 447).

[2] J. E. Harting, *Zoologist*, 1895, 421.

[3] J. H. Blasius, *Säugethiere Deutschlands*, 329.

Although some observers have found difficulty in inducing Harvest Mice to breed[1] or to rear their young[2] in captivity, others have met with more success. Mr Southwell[3] records two produced in captivity, but gives no details; de l'Isle's[4] captives bred twice; those kept by Mr Harting[5] bred and reared their young, and the latter became very tame.

Although they do not become as tame as Field Mice, a colony of Harvest Mice make clean and interesting pets, being easily fed and devoid of unpleasant odour. Dr H. Laver has found them peaceable in winter, but in spring the males fight and devour each other, and the young were always eaten after a few days.[6] Mr English finds a similar peaceable amiability combined with an unpleasant tendency to run amuck, sometimes resulting in the slaughter of most of the colony, and thus showing a very different temperament from that of the Field Mouse. Mr Tomes (in Bell, ed. ii.), describes it as gentle and not ready to bite, but requiring exercise. Mr Rope,[7] on the contrary, says that it bites savagely when handled, hanging on like a bulldog, and moving the jaws about while the teeth are still in the wound—in which it resembles the House Mouse and the Field Mouse.

The Harvest Mouse appears to live naturally on a mixed diet of seeds and insects. Mr Waters observed it pausing in its labour of nest-building to partake of a head of corn. As in the case of the Field Mouse, the range of dainties accepted in captivity is a wide one. Its insectivorous tastes were accidentally discovered by Bingley,[8] who saw his mouse spring at a passing bluebottle; Bingley caught the fly and made it buzz against the wires of the cage, whereupon "the mouse, though usually shy and timid, immediately came out of her hiding-place, and running to the spot, seized and devoured it." Afterwards, fed with insects whenever possible the mouse "always preferred them to every other kind of food" offered. Mr

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[1] Eliza Brightwen, *op. cit.*, 137.

[2] Dr H. Laver, *op. cit.*

[3] *Zoologist*, 1871, 2756.

[4] *Ann. Sci. Nat. Zool.*, 1865, 181.

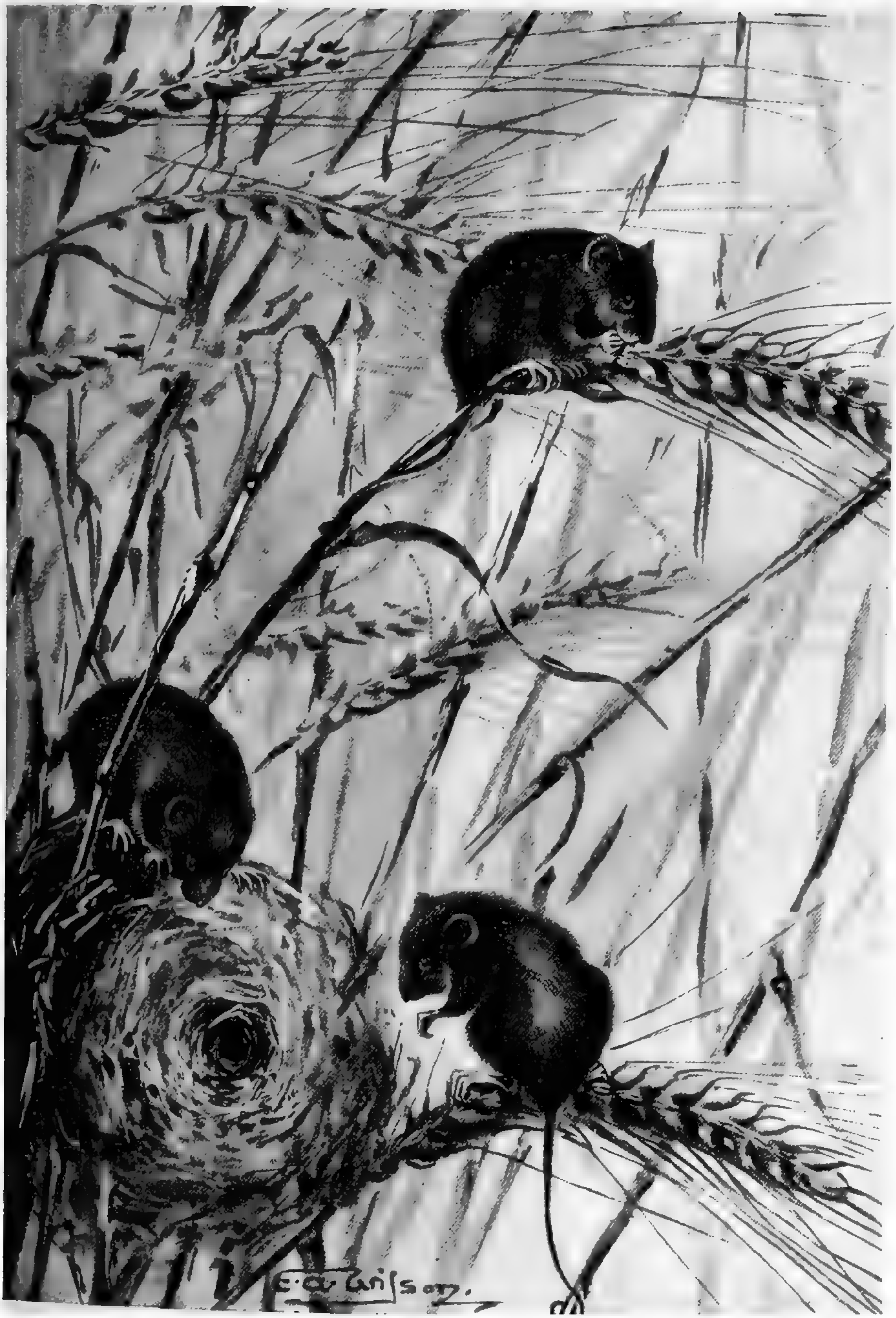
[5] *Field*, 2nd January 1875; *Zoologist*, 1895, 421; and in Lydekker, 183.

[6] Gurney, *Zoologist* 1884, 112, prevented this cannibalism by giving the mice a mutton-chop bone; he observed a large specimen begin to eat a smaller one's ear, the victim quiescent. See also Rope, *op. cit.*, 1884, 57; and Eliza Brightwen, *Wild Nature Won by Kindness*, 1896, 138.

[7] *Op. cit.*, 1884, 58.

[8] *British Quadrupeds*, 1809, 268.

PLATE XXXI.



Harvest Mouse. ($\frac{2}{3}$ natural size.)

E. Newman[1] also observed that bluebottles were a favourite food; according to Mr H. H. Crewe[2] another captive ate bluebottles and other flies, butterflies, moths, bees, wasps, lepidopterous larvæ, and especially cockroaches, of which it was known to eat fourteen in a night, seizing and worrying large ones; it also ate wheat, barley, oats, biscuit, cake, apple, nuts, bread and milk; but its favourite food was insects. Mr Rope's specimen ate broom-seed, wood-lice, and flies; describing its methods of catching the latter, Mr Rope[3] says that the mouse sits still until a fly buzzes near it, when, without apparent effort, it is "firmly grasped in the paws," and rapidly devoured, the wings and elytra being generally rejected. Mr Gurney's mice loved burrowing into fresh clayey moss; they were very fond of canary seed, and ate the twigs and early leaf-buds of hazel, as well as pieces of cooked meat off a mutton-chop bone.[4] Mrs Brightwen[5] mentions that her mice ate insects, canary seed, brown bread, and that they burrowed for growing corn. Millais[6] says they eat seed, shoots, and tender leaves; they enjoy all cereals, preferring wheat, but not caring for bread. In eating wheat, as described by Mr Rope,[7] the mouse sits up and holds the grain in a horizontal position between the fore paws, one at each end, then revolving the grain rapidly, it slices off the outer skin with its incisors until it obtains the clean white corn.

Like most murines the Harvest Mouse shows, at all events occasionally, a propensity to lay up a store of provisions; and those that remain in the field are said to form stores for the winter season, and congregate in small societies in the holes under some sheltered ditch bank.[8] In this connection one of Bingley's[9] observations may be quoted. His mouse made a nest of flannel and grass; on opening this nest about the latter end of October 1804, he "remarked that there were, among the grass and wool at the bottom, about forty grains of maize. These appeared to have been arranged with some care and regularity, and every grain had the corcule, or growing part, eaten out, the lobes only being left." Bingley soon afterwards put into the cage about a hundred additional grains of maize.

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[1] *Zoologist*, 1867, 911.
[2] *Op. cit.*, 1867, 554.
[3] *Op. cit.*, 1884, 57.
[4] *Op. cit.*, 1884, 112.
[5] *Op. cit.*, 138.
[6] Millais, ii., 179.
[7] *Op. cit.*, 1884, 56.
[8] Knapp, *Journal of a Naturalist*, 139.
[9] *Op. cit.*, 269.

These were all in a short time carried away, and on a second examination, he found them "stored up in the manner of the former. But though the animal was well supplied with other food, and particularly with bread, which it seemed very fond of, and although it continued perfectly active through the whole winter, on examining its nest a third time, about the end of November," he observed "that the food in its repository was all consumed, except about half-a-dozen grains." Much of the animal's work of transporting the grass for its nest must have been done during the night.

Captives lap milk and water (Bingley, *op. cit.*, 268; Harting, *op. cit.;* and Millais, ii., 180).

The voice is said to be not pitched so high as that of the House Mouse, and to be rather "a harsh grating chirp than a squeak."[1] Mrs Brightwen[2] says that sometimes "in their great happiness they make a low, sweet chirping like a company of wrens conversing cheerily together."

Harvest Mice are very difficult to trap, and are usually caught by hand when leaving or entering their nests; this accounts for the dearth of really mature material noticed above. Their numbers, like those of "voles" and Field Mice, are subject to annual fluctuations, and in a "mouse year," at least on the Continent, they may form a considerable proportion of the total rodent population.[3] When present in large numbers, they are capable of causing much damage to crops despite their diminutive size; but their ravages are largely compensated by their insectivorous tastes.

As regards its longevity, Bingley's specimens lived for two and a quarter years in confinement, while Mrs Brightwen's[4] specimens began to die after two years' captivity; the longest lived one of ten kept at the Zoological Gardens remained there for thirty-three months.[5]

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[1] G. T. Rope, *op. cit.*, 1884, 57.

[2] *Op. cit.*, 138.

[3] Schlegel, *Zoologist*, 1881, 234; Blasius, *op. cit.*, 329; Landois, *op. cit.*, 163; and S. A. Poppe, *op. cit.*, *supra.*

[4] *Loc. cit.*

[5] P. Chalmers Mitchell, *Proc. Zool. Soc.*, 1911, 448.

GENUS EPIMYS.

1867. RATTUS, L. Fitzinger, *Sitzungsb. kais. Akad. Wiss. Wien., math.-nat. Cl.*, lvi., Abt., 1, 63, included *rattus*, *decumanus*, *alexandrinus*, and others; antedated by RATTUS, Donovan, *Naturalist's Repository*, iii., pl. 73, page unnumbered, 1827, based on *R. donovani* from the Cape of Good Hope. (RATTUS, Frisch, *Das Natur-System vierfüss. Thiere, in Tabellen*, 7 Tab. gen., 1775; and RATTUS, Zimmermann, *Specimen Zool. Geog. Quad.*, 344-7, 1777, are not regarded as valid.)

1881. EPIMYS, E. L. Trouessart, *Bull. Soc. d'Études Sci. d'Angers*, x, 117 (subgenus); based on *Mus rattus* of Linnæus (type); Miller, *Proc. Biol. Soc.*, (*Washington*), xxiii., 58, 19th April 1910 (genus); Thomas, *Ann. and Mag. Nat. Hist.*, December 1910, 604 (genus).

MUS of most authors.

Classification:—In 1910, Miller adopted Trouessart's name, *Epimys* (originally proposed as a sub-genus, of which *Mus rattus*, Linnæus, is the type), as the generic name of the House Rats, and restricted the Linnæan genus *Mus* to *Mus musculus*, Linnæus, and its allies. The genus *Epimys* was further defined by Thomas (cited above).

As now understood, *Epimys* is the largest genus of the sub-family, and includes a great number of Asiatic, Malayan, African, and Australian species. Many of these species, particularly in Africa, are of small size, and would be termed generally "mice" rather than "rats."

The genus is doubtless of Oriental **origin**, and in view of its wide natural distribution it must date from a comparatively remote epoch.

In **Europe** it may have been represented in the late Pleistocene (see p. 588); but if then present it subsequently died out. It is now represented here only by the two well-known species of true rat, *E. rattus* and *E. norvegicus*, both of which are comparatively recent immigrants from the East. *E. rattus* appears to have been introduced about the time of the Crusades, while its rival, *E. norvegicus*, did not appear here before the beginning of the eighteenth century. These two species owe their introduction to Europe, and their more recently acquired cosmopolitan distribution, to their parasitic habits, and their readiness to take advantage of the facilities for travel afforded by human commerce.

In this genus the external form and skull characters are essentially those of typical or but slightly specialised *Murinæ*.

The **skull** is strongly built, with well-marked supra-orbital ridges, which generally extend back to the outer corners of the inter-parietal; the front edge of the zygomatic plate is always convex; the posterior border of the palate is a simple shelf; the pterygoids are thin plates, and the pterygoid fossæ are deep and well defined. The **incisors** are much deeper than broad, and their wearing surfaces are normal and unnotched. The **cheek-teeth** (Pl. XXVIII., Figs. 8 and 9) are characterised by the complete suppression of cusps 7 and 3 in upper molars, which have consequently never more than three outer and two inner tubercles. The tubercles show a nearly transverse arrangement, and because of this and the more or less relatively large size of those forming the median row, the teeth, in the higher species, acquire something of a lophodont or laminated character—a feature which becomes better marked in certain more highly specialised Oriental relatives, e.g. *Nesokia*. $m\frac{1}{1}$ are never longer than the combined length of $m\frac{2}{2}$ and $\frac{3}{3}$; $m\frac{3}{3}$ show no tendency to disappear.

The **mammæ** vary from six to twelve or more; typically there appear to be three pectoral and three inguinal pairs, and, so far as is known, at least one pectoral pair is present in all species.

The **young**, born naked, soon acquire a soft, thick, and mole-like pelage, in which as a rule the dense underfur is grey; their colour is largely dependent upon this underfur; the upper parts are therefore greyer than in adults, and the belly is dark grey. The **moult** appears to take place usually in a gradual and inconspicuous manner, but in some Indian specimens of the *rattus* group the new fur of the rump is sharply separated from the old coat remaining on the head and shoulders.

The true rats may be regarded as the most successful of existing terrestrial mammals. Their activity, intelligence, prolificacy, and power of procuring and assimilating a great variety of foods are all of a very high order. The higher species are at home in all climates and under all conceivable conditions, except perhaps extreme cold. They accompany our ships to sea, and swarm in our houses. Although highly palatable, their cautious and cunning habits, their vigorous courage and high powers of defence and offence, enable them to attain a size which would be fatal to the continued existence of the more sluggish-minded mice. They dig, swim, climb, and run with equal facility, and in turn assume with perfect indifference the rôle of rodent or carnivore. Their social system is so arranged as to avoid useless conflicts with members of their own species; and in times of hunger or scarcity they may unite to subdue game far above the powers of a single member of their race.

They are probably the greatest mammalian pests of the human race, and the account against them has been vastly increased by the discovery that they are the bearers of bubonic plague,[1] which they transfer to man by means of fleas, chiefly *Xenopsylla cheopsis* of N. C. Rothschild. Apart from plague, they cause enormous trouble, expense, and many deaths by being the primary host of *Trichinella spiralis* of Owen, which they transfer through pigs to men; by being carriers of equine influenza and of "foot and mouth" disease (see Shipley, "Rats and their Animal Parasites," *Journal of Economic Biology*, 1908, iii., pt. 3, 61-83). For a list of rat fleas, see N. C. Rothschild, *Bull. Entom. Research*, i., 1910, 89; for rodents and plague, see H. B. Wood, *Amer. Nat.*, 1910 (*Nature*, 4th August 1910, 149). W. C. Hossack (*Memoirs of the Indian Museum*, vol. i., No. 1, July 1907, 1-80, and plates i.-viii., 1907), discusses the rats of Calcutta, and states that *Nesokia bengalensis* is the rat concerned with plague there.

Their rapid growth and high fecundity cause both *norvegicus* and *rattus* to be suitable subjects for Mendelian research, the results of which, so far as they concern systematic questions, are dealt with below under the species.

All attempts at securing hybrids between these two species have failed hitherto. In ordinary circumstances the natural aversion of the species leads the stronger partner to bully or slay the weaker, unless great care is taken; but young individuals of the two species have been paired, and have lived for long periods harmoniously together (de l'Isle, Morgan, and others). The method of copulation differs in the two species, and this of course occasions difficulty also. Lataste (376-9), however, overcame both difficulties and engineered effective copulation (*i.e.* with the production of a vaginal bouchon), but the unions were infertile; his friend C. Mailles was also unsuccessful. Iwanoff (*Arch. des Sci. Biol.*, xii., 1907, 376; Marshall, 609) artificially inseminated a white mouse with spermatozoa of a white rat; two hybrid young, intermediate in size between mice and rats, were produced after a pregnancy of twenty-seven days.

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[1] Plague:—*Field*, 31st December 1910, 1237 ("Country House"); *Nature*, 1911, 29th June, 592; 6th July, 18; 9th November, 56; 1912, 18th April, 177.

Exceptional variation:—Specimens of rats and mice with the skin corrugated and devoid of hair have been occasionally reported; for instances and references, see *Proc. Zool. Soc.*, London, 1856, 38, and 1903, 336. Albinic or melanistic individuals are not uncommon. Tailless and other physically deformed rats are known, but such deformities appear usually to be the results of injuries.

Two species have to be described as **British**, viz., the Black or Ship Rat (*E. rattus*), and the Brown or Common Rat (*E. norvegicus*).

1. THE BLACK OR SHIP RAT.

EPIMYS RATTUS, Linnæus.

For **synonymy**, see below under sub-species.

Le Rat Noir of the French: *die Hausratte* of the Germans.

Terminology:—Rats (late Latin *ratus* and *rattus*, of uncertain origin (*N. E. Dict.*), but possibly derived from *rapere* (de l'Isle), *radere* (Skeat), or *rodere* (*Cent. Dict.*)) are not mentioned in the *Epinal Glossary* (about 700 A.D.), where the word *mus* is applied to shrews. They appear first about 1000 A.D., in Archbishop Ælfric's *Vocabulary* (ed. Wright-Wülcker, 1884), where *raturus* = "ræt." According to the *New English Dictionary* the word appears to have been adopted from the Latin first by the Teutonic languages in the form *ratton*, and later by the Romance tongues; the converse view, however, has been advanced by de l'Isle (see p. 582), and it seems probable that prior to the Crusades the name was applied to the House Mouse (see p. 579). In the Latin writings of Giraldus Cambrensis (1147-1223) rats are perhaps first clearly distinguished from mice; while in the *Vision of Piers Plowman* (1377), B. Prol., 146 and 200, "a route of ratones. . . . And smale mys with hem" are mentioned. Shakespeare, *Tempest*, Act i., sc. 2, 147, 1610, has: "Nor tackle, sayle, nor mast; the very rats instinctively have quit it"; and also *Measure for Measure*, Act i., sc. 2: "Rats that ravin down their proper bane."

Earlier British writers knew only one rat, viz., *rattus*, which Ray called "The Rat." In the earlier editions of Pennant (1766 and 1768), and in Berkenhout (1769), the Common Rat of the present day makes its appearance as the "Norway Rat," *rattus* being still the "Common Rat." Late in the eighteenth century (from Pennant, 1792 onwards), the two animals became known as the "Black" and "Brown" rats, and there has since been no change of usage. These names are not, however, very appropriate, since there are black varieties of the "Brown Rat," while a brown form of the "Black Rat" is very common or universal in several Eastern countries, and is well known as the "Alexandrine Rat." At the present time the most appropriate names for the two animals would seem to be the "Common Rat" and "Ship Rat," thus emphasising their chief British characteristics, and avoiding the ambiguities of terms based on differences of colour.

Local names:—

(Non-Celtic):—"Blue Rat" of Orkney and Channel Islands.

(Celtic):—Irish—*Franncach* = "Frenchman"; or *luch fhranncach* = "French-mouse"; *luchog mhor* = "big mouse" (as in Clare Island, Colgan, *Proc. R. I. Acad.*, xxxi., 4, 22, 1911); *galluch* = "foreign mouse" (C. M. Robertson); *raftan*, from English *ratten.*

Scottish Gaelic—*Radan* (C. H. Alston), or *rodan*, from the English "rat"; *radan dubh* = "black rat" (C. H. Alston).

Manx—*Roddan* = "rat."

Welsh—*Llygoden ffrengig* or *llygoden ffreinig* = "French-mouse"; *llygoden fawr* = "big mouse."

Cornish—*logosan vras* = "big mouse."

The name "French-mouse," although perhaps at first used in its literal meaning,[1] soon came to signify, at least in Ireland, merely "foreign mouse" (*cf.* Irish *eun francach* = "the French bird" = the turkey; and Welsh *crian ffreinig* = "French nut" = walnut); later the epithet was dropped, and both rat and turkey became known to the Irish simply as *francach.* Much useful and interesting information is collected in D. Comyns's *Irish Illustrations to Shakespeare*, 1894.

History and Distribution in Europe:—The Black Rat, using the name to cover the wild forms as well, was not known to the ancient Greeks and Romans. The occurrence of the word *ræt* in Archbishop Ælfric's *Vocabulary* (cited above) perhaps indicates that this animal was known to the English prior to 1000 A.D.; but since the word *rata* was the name of the House Mouse among the Provençals, it is possible that a similar signification may have attached to the Anglo-Saxon word. Some writers, as F. Cuvier (*Hist. Nat. Mammifères*) and Tomes (in Bell, ed. ii., 303), think that its establishment in Europe dates from the sixteenth century only, and they cite Gesner as the first describer. Others suppose that the Black Rat arrived in Europe in the Middle Ages, and they rely on Albertus Magnus, who wrote in the middle of the thirteenth century, "*Est autem magnum quod nos ratum vocamus: et est in arboribus habitans, fuscum nigris in facie maculis* (*De Animalibus*, lib. xxii., 182); but this passage, as pointed out by de l'Isle, is a description of *Eliomys*, and may be cited as a proof that rats were unknown at Cologne, Germany, when it was written. They were certainly known in France in the early thirteenth century, since they are clearly indicated in the well-known ballads of Reynard (*Roman du Renart*, early thirteenth century; *Renart le nouvel*, late thirteenth century; and *Renart le contrefait*, early fourteenth century). Beyond the evidence of the legendary *Pied Piper of Hameln*,[1] no such early German record is known (but see under *Distribution in Time*, p. 588).

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[1] But, as Mr Cocks points out, the adjective "French" has long, and until quite recently, been generally used for anything "foreign."

In England rats were considered nuisances in the thirteenth and fourteenth centuries (Rogers, i., 33). They were caught at Weston in 1297, and in Oxford on two occasions, in 1335 and 1363: in the former case a farthing apiece was paid for them, a circumstance which caused Rogers to think that, in the general practice that prevailed of using fur of all kinds, rat skins had a market value (*op. cit.*, 282). Arsenic as a poison was known (*op. cit.*, 33), and Chaucer has (in the *Pardonere's Tale*): "And forth he goth, no lenger wold he tary, Into the toun unto a Potecary, And praied him that he him wolde sell Som poison, that he might his ratouns quell." A femur was obtained from the midden of Rayleigh Castle, Essex, a stronghold occupied from the end of the eleventh to the beginning of the thirteenth century, but the whitish colour of the bone suggested that the specimen might be "somewhat more recent than most of the remains from the midden."[2]

The bones of "rats" found by J. P. Bartlett in Romano-British tumuli were in all probability remains of the Water Rat. References to rats occur in the *Master of Game* (218) and in Turberville (1575, 147), where they or mice are spoken of as food for falcons. Elizabeth's *Acte for ꝑservacon of Grayne* set a price of one penny "for the heades of everie three Rattes or twelve myse."

In Ireland the Black Rat was probably numerous and well known from at least the twelfth century, for we have Giraldus Cambrensis's statement[3] (*Topographia Hibernica*, 1183-1186): *Est et aliud ibi* (*i.e.*

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[1] According to this legend Hameln suffered a terrible plague of rats in 1259 or 1284. The piper attracted the rats with his music, and led them to destruction in the Weser. The citizens cheated him of his reward; whereupon the piper re-entered the city on 26th June, played another tune, and drew all the children, save a lame one, after him into the interior of the low hill called the Koppenberg. The records of the town were long dated from the latter tragic event.

[2] Hinton, *Essex Naturalist*, xvii., 17, 1912.

[3] See Millais, ii., 209, for other references to rats by Giraldus in Ireland and Wales.

in insula Aran in occidentali Connactiæ solo posita) *notabile : quia cum per totam Hiberniam copiose nimis mures abundent, haec tamen insula mure caret. Mus enim nec nascitur nec vivit invectus.* (There is another thing remarkable in this island—although *mures* swarm in vast numbers in other parts of Ireland, here not a single one is found. No *mus* is bred here, nor does it live if it be introduced.) The island, however, was probably not Aran, as suggested above, but Inishglora, or Caher, both in Co. Mayo, the sanctity of each of which was so great that no rat or mouse could live for even a few minutes on their shores; the earth of these islands drove rats and mice from any house on which it was sprinkled—see Browne, *Proc. Roy. Irish Acad.*, v., December 1898, 64; Westropp, *Proc. cit.*, xxxi., 2, 1911, 53.

The words *mus* and *mures* in the above passage are usually translated "mouse" and "mice," as in Bohn's edition of the *Topographia*, 64; but there is no evidence that Ireland, which has no "voles," ever suffered from superabundance of mice, and the word *mures*, to which Higden, writing his *Polychronichon* in the following (fourteenth) century (he died in 1363), added the word *nocentissimos* = "most harmful," was almost certainly applied to the Black Rat, *Epimys rattus*, which was at that time, as stated above, already quite well known in England and considered a nuisance. It probably made its way to Ireland quite as early as to England, since the Irish are known to have traded freely with England and Europe from at least the thirteenth century. Unfortunately, O'Flaherty (*Chorographical Description of West or H-Iar Connaught*, 1684) misinterpreted Giraldus, writing that "it (*i.e.* West Connaught) admits no rats to live anywhere except the isles of Aran, and the district of the west liberties of Galway," which is a reversed translation of Giraldus, but is important, as it accepts the meaning of *mures* as "rats."

About 1377, "rats or mice" are mentioned as doing damage in the Register of Archbishop Sweteman of Armagh (Lawlor, *Proc. Roy. Dublin Soc.*, xxiv., c. 8, 264, 1911).

In subsequent years rats were generally well known in Ireland, the common belief at the end of the sixteenth century being represented by four lines quoted by Fynes-Moryson (1559-1603; *op. cit. supra*, p. 326):—

"Quatuor hybernos vexant animalia, turpes
Corpora vermiculi, sorices per tecta rapaces.
Carnivori vastantque lupi crudeliter agros
Haec tria nequitia superas Romane sacerdos."

For four vile beasts Ireland hath no fence:
  Their bodies lice, their houses rats possess;
Most wicked priests govern their conscience,
  And ravening wolves do waste their fields no less.

The Irish practice of satirising or rhyming rats (and other animals) to death was frequently mentioned in the seventeenth century, starting, perhaps, with Scott's *Discoverie of Witchcraft* (1584). Thus Shakespeare made Rosalind say, in *As You Like It*, Act iii., sc. 2: "I was never so be-rhimed that I can remember since Pythagoras's time, when I was an Irish rat"; and the same idea is found in Ben Jonson's *Poetaster* (address to the reader; 1601): "Rhime them to death as they do Irish Rats"; in the same author's *Staple of News* (1625); in Randolph's *Jealous Lovers* (1646); Flecknoe's *Characters* (1665); and doubtless numerous other references could be given.

E. rattus is undoubtedly of Eastern origin. There is no clear evidence of its presence in Europe during the historic period prior to the Crusades (1095, 1147, and 1191); on the other hand, as shown above, the species was firmly established in western Europe shortly after those events, and there can be little doubt that it was imported by the navies of the Crusaders. De l'Isle's researches led him to believe that the Alexandrine[1] Rat was the parent source of the European Black Rat. He supposed that in the seventh century the "Alexandrine Rat" was still living a free life on the deserts of Arabia, because if it had been parasitic on man in the Near East at that time the torrent of Arab invasion would have brought it to Europe, whereas it did not appear in Europe until three or four centuries later. Subsequently it acquired parasitic habits, and it spread through Palestine, Egypt, and North Africa. From the Levant the ships of the Crusaders carried it to the northern shores of the Mediterranean, where it received a variety of names. The modern Greeks called it ποντικος, the Venetians *pantegana*, in each case in allusion to its arrival by sea; the Genoese named it *Topo* (a modification of *Talpa*), which is still used in Italy; the Romans called it *Sorco* (from *Sorex*); finally, in Provence, where the word *rata* was used as the name of the House Mouse, it received the name *rat*, and this Provençal name, as the animal spread into the cities of other Western peoples, followed it into all the languages of western Europe.

According to de l'Isle, the pioneer rats must have had brown backs and light bellies, and in Italy and Iberia this colour has been retained. Northwards of the Mediterranean region the brown pelage was changed, partly by climatic influences (as supposed by de l'Isle) and partly because of alimentary changes (according to Fatio), into a black one. This change cannot have taken longer than three centuries, or more than 900 generations of rats, to effect,[2] for Georgius Agricola (*De Animant. subterran.*, 1530, ed. 1657, 485) described the rat as "*Mus*

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[1] De l'Isle meant the form called *E. r. frugivorus* below; see p. 595, footnote 1.

[2] If, as seems probable, the race arose as a Mendelian mutation (see under Geographical variation), the change was probably effected in a much shorter period.

major mole corporis mustelæ minimæ; pilis est subnigris; cauda procera, etc." In 1551, Gesner (*De Quadrupedibus*, 1, 829) described it as follows: "*colore subniger, vel fuscus, qui ventrem versus dilutior est*," and in the rare copies in which his figure is coloured he depicts a rat of intense dusky hue.

Beyond the fact that it was later than in France or Britain, and that it must have been before the sixteenth century, nothing is known of the date of the introduction of this species to Germany. In Denmark, according to Winge, it did not appear until late mediæval times or even later. The first mention of it in Norway, according to Collett, was by P. Claussön, who stated, in 1599, that it was brought to that country by ships, and that it subsequently acquired there an extensive distribution, although only along the coast and in the market-towns; in 1613 the same writer added that it had been carried by shipping to the country north of Trondhjemfjord, but that it did not survive in that region long.

The Black Rat quickly multiplied in Europe and soon became a most formidable pest. War was waged against it with poison as early as the fourteenth century (see p. 580 above); a rat-trap is spoken of in the accounts of the churchwardens of St Michael's, Cornhill, London, for the year 1469; Shakespeare alluded to the rat-catcher[1] in 1592 (*Romeo and Juliet*, Act iii., sc. 1, 78); and doubtless most of the ordinary methods of destroying rats were familiar at an early date. So serious were the ravages of this species in some places, and so fruitless were the attempts made to exterminate it, that on various occasions appeals were made to the spiritual powers for protection. Thus Blasius mentions that at Nordhausen the people held a day of prayer on its account; while in the beginning of the fifteenth century the Bishop of Autun formally placed the animal under a curse.

Early in the eighteenth century the invasion of Europe by the Brown Rat began; and as this stronger and more fecund rival gained ground, the Black Rat waned in numbers, until at length it became extinct over a large part of its former domain in temperate Europe. This ousting of the Black Rat may have been in part due to a direct antipathy between the two species, and partly to the greater voracity of the Brown Rat, which perhaps tended to deprive the weaker species of provisions.

Robert Smith, rat-catcher to the Princess Amelia (*The Universal Directory for taking alive and destroying Rats, etc.*, 1768), describes the

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[1] The same personage figured long before in *Piers Plowman*, A. v., 165 (1362) as "a ratoner." Pennant (*British Zoology*, ed. 1776, 101) states that "among other officers, his *British* majesty has a *rat-catcher*, distinguished by a particular dress, scarlet embroidered with yellow worsted, in which are figures of mice destroying wheat-sheaves."

Black Rat as in his day living in ceilings and wainscots, the "Norway Rats" in shores and sewers. He relates how he at one house caught the latter in the cellars, but in the upper part of the house nothing but Black Rats; he put all together in a great cage, intending to show them to his employer in the morning, but the Norway Rats promptly killed and devoured the Black Rats in his presence. Thomas Swaine, in *The Vermin Catcher*, 1783, states that in the fifteen counties in which he worked he never met Black Rats except in Bucks—a few in High Wycombe—and Middlesex; while in the city of London he found very few Norway Rats, but quantities of Black Rats. He thought the Norway Rats came from the shipping in the Port of London, and dispersed to country districts, where they were better able to master the Black Rats. In 1776 Pennant (*Brit. Zool.*, i., 101) noted that "the Norway rat has also greatly lessened their numbers, and in many places almost extirpated them"; and Goldsmith (*Nat. Hist.*, iv., 66, 1776) referred to it as "the Common Rat, as it was once called, but now common no longer."

Donovan (1820) speaks of it familiarly—and he observed the expulsion from a house in London of a numerous colony by Brown Rats. Frank Buckland quotes a passage showing that about 1850, certain of the older granaries of the Metropolis were still tenanted by this species, and in Bell's ed. ii. (303) it is said that they could still be found in old houses in London[1] and Edinburgh; but Macgillivray stated in 1838 that he had not seen a specimen captured in the latter city within the preceding fifteen years. About 1860 it "was not rare in Warwickshire, but we now doubt the possibility of obtaining a single example" (Bell, ed. ii., 303). It is said to have recently existed in Westmoreland in small numbers about fell-side farms (J. Goodchild, *Lakeland*, 80, 1883), and it was reported from parts of Cheshire as still not uncommon in 1890 (Coward and Oldham). No doubt many whose memories went back to the second quarter of the nineteenth century could recall unexterminated colonies of Black Rats; but the identification cannot always be trusted, for in many cases there has been confusion with *hibernicus*, the black race of the Brown Rat. For an account of these various records, see Harting (*Field*, 26th July 1879, 144; and *Essays on Sport and Nat. Hist.*, 156-170, 1883) and Millais (ii., 207).

As regards rural Scotland, it was described in 1813 as the only species met with in Forfar, and as being not rare in all the inland districts of Angusshire (Don, Appendix, 38; in Hendrick, *Agriculture of Forfar*). They were common in Aberdeenshire until about 1830. The Rev. G. Gordon sent specimens from Elgin, where, however, it was much less common than the Brown Rat, to Macgillivray; and the latter, in 1838, said that "in Keith, which is at a greater distance from the coast, it is not very uncommon," and that it could still be procured in other inland towns and villages in Scotland. It was stated by Charles St John (*Wild Sports in the Highlands*, 76) to be extinct in Moray in 1850, although plentiful there twenty years before; the Rev. G. Gordon (*Zoologist*, 1844, 424) said that it occurred in this county in 1844, but he reported it to E. R. Alston as extinct in 1880. The small colony of black rats observed by Colonel Drummond-Hay in 1860, occupying a drain in the vicinity of Pitlochry (Bell, ed. ii., 303), may have been of the black race of *norvegicus* (*hibernicus*), or even black water-rats (*A. a. reta*). But Millais saw, in 1879, two undoubted Black Rats which had just been captured from a small colony discovered in a shop in Dunkeld. In 1651 it was stated that "a rat cannot live in Sutherland." "There is not a ratt in Sutherland . . . they die presently how soon they doe smell of the aire of the country. But they are in Catteynes, the next adjacent province, divyded onlie by a little strype or brook from Sutherland" (*Hist. Earldom of Sutherland*, 1813; J. A. Harvie-Browne, *in lit.*). In the Hebrides it is stated to be still extant on Benbecula (Harvie-Brown and Buckley, 36).

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[1] Mr Cocks has called our attention to the discovery of a colony in 1875 in a house on Cornhill, London; see also *Land and Water*, May 1874, 399.

The Black Rat inhabited the Orkneys, where it was known as the Blue Rat (J. Wolley, *Zoologist*, 1849, 2344; J. M. B. Taylor, *Ann. Scott. Nat. Hist.*, 1900, 181). Barry (*Hist. of the Orkney Islands*, 1808, 320) says that it "was formerly numerous, and as destructive as the rest of the genus; but it has of late been confined to one or two of the islands, owing to the Brown Rat, which has almost entirely extirpated them through the rest of the country. In size and strength it is inferior to its adversary, but not in its disposition to plunder; and when once it has established itself in a place, there are no means known of expelling it." In 1813 Low (*Fauna Orcadensis*, 22) stated that it could still be found in South Ronaldshay, whence Barrett-Hamilton received one from T. E. Buckley in 1892 (*Ann. Scott. Nat. Hist.*, 1892, 267). W. Evans informs us that this colony was still in existence three years ago.

In the Shetlands, Millais believes that it is frequently killed at Lerwick. In 1904 he observed three dead specimens lying on a wharf in front of a store on Whalsey; these were Alexandrines (brown above, with grey bellies); Mr Nicholson, the owner of the store, told Millais that twenty years before these long-tailed rats were common, but they subsequently died out; in 1900 they were reintroduced by a German vessel, and they had since become very numerous about his storehouses and were a great pest.

The Black Rat is believed to occur in Scilly, but we have seen no specimens. Coward obtained all three sub-species of *rattus*, together with *norvegicus*, upon Lundy. In the Channel Islands they were stated by Ansted (*Channel Islands*, ii., 201, ed. 2, 1862) to be "common in Alderney and Herm." They are known from Jersey, where they are pretty numerous, especially in the east; Guernsey, where they are also in fair number; and Sark, where they are abundant, there being no Brown Rats, and all landing being made by boats; this colony is of interest, inasmuch as it appears likely to be one of the last remnants of the original *rattus* stock. On Herm these rats are said to be stronger and more robust than on Sark, and to have longer hair on their backs (35 mm.). The "Blue Rat" of the Ecrehuo Rocks, a few miles to the north-east of Jersey, is *rattus* also; the species is becoming rare on all the islands with the exception of Sark (see R. H. Bunting, *Zoologist*, 1908, 464).

The species is now very rare in Ireland. Thompson (*Nat. Hist. Ireland*, v., 16, 1856) received one from Co. Cork in December 1842 (see Harvey, *Fauna of Cork*, 2), and he records it as then resident in various localities in Kerry, Armagh, Dublin, and Antrim; but Barrett-Hamilton (*MS.*), fearing confusion with *hibernicus*, doubted these latter records. In turn, Barrett-Hamilton stated this species to be not uncommon in the neighbourhood of his home at Kilmanock (*Zoologist*, 1887, 425; and 1888, 141); but no mention of these is to be found among his later manuscripts, and the old skins in his collection from Kilmanock are all referable to *hibernicus*. Barrington mentions a litter of Black Rats found at Levitson, Co. Kildare, in 1876. In 1911 Ussher discovered a colony in a corn-store at Dungarvon, Co. Waterford; he sent specimens to the Dublin Museum and to Barrett-Hamilton, from whom Hinton received one.

In Norfolk, Black Rats were considered rare and almost unknown by Southwell, but in 1895 Patterson discovered the species living in considerable numbers in certain parts of Yarmouth. This colony appears to be well established; it is chiefly composed of true *rattus*, the brown or wild-coloured forms being rare.

In 1905 Patterson (*Nature in Eastern Norfolk*) reported it as having never before been so numerous at Yarmouth. He says that in 1895 it forced itself into notice by an apparent increase, although strangely enough it seemed to flourish only in the south-western corner of the town, Regent Street then forming a boundary of its northern distribution. Patterson obtained over 100 examples within a few months, besides a great many from fishing-smacks. In the summer of 1896 Black Rats became troublesome in private houses, warehouses, and stores. At one grocer's store, where these rats had caused much trouble, the Brown Rat made its appearance, and the supply of Black Rats suddenly ceased as if they had fled, although they still swarmed in a neighbouring dwelling (*Zoologist*, 1901, 153). In 1906 and 1907

Patterson (*Zoologist*, and *Wild Life on a Norfolk Estuary*) reported that the rats were still apparently increasing in numbers and occupying fresh haunts; and he wrote that they were still abundant in 1910. Specimens taken by Patterson were sent by Southwell to Barrett-Hamilton from Yarmouth in 1896.

If the Brown Rat has displaced the Black Rat from a large part of Europe, the latter species is still unrivalled in the rôle of a mariner. As such it frequently makes a reappearance in ports and along coasts whence it has, as a landsman, long since vanished. Sometimes it comes ashore from wrecks. Thus T. Cornish (*Zoologist*, 1878, 388) notes that after the wreck of an Italian grain-ship, the *Espagnol*, in Acton Cove, Marazion, Cornwall, "the whole of the surrounding district was swarming with these little rats." The "English Black Rat" is also mentioned as "although rare in this district, not extinct," and Cornish recorded its occurrence in Cornwall in 1889 (*Zoologist*, 1889, 434 and 450). Again, a "breed" of black rats swam ashore at Seascale from the wreck of a foreign fruit-vessel in 1866, and became temporarily established (T. Lindsay, in *Lakeland*, 81); and another important description of a landing (on Man) of these foreign rats is given by Millais (ii., 213). A constant interchange of rats takes place between vessels lying in port and the land, but owing to the relatively small numbers of rats involved, such movements naturally attract attention less frequently. When at Marseru, Basutoland, about 1904, Mr Wroughton saw three specimens of *E. r. rattus* which came out alive from packing-cases imported by the hospital; these packages had come by sea from Europe to East London, and thence by rail, followed by over a month's trek.

Distribution and status:—*E. rattus* is naturally distributed throughout southern Asia. Semi-parasitic races (*E. r. frugivorus* and *r. alexandrinus*), retaining the wild coloration, have spread thence by way of Asia Minor and Arabia throughout Africa north of the Sahara and throughout the south of Europe. These on colonising temperate Europe have become completely parasitic, and have developed as a peculiar dusky race or sub-species, *E. r. rattus*. These parasitic races have been subsequently dispersed artificially though unwittingly throughout the world.

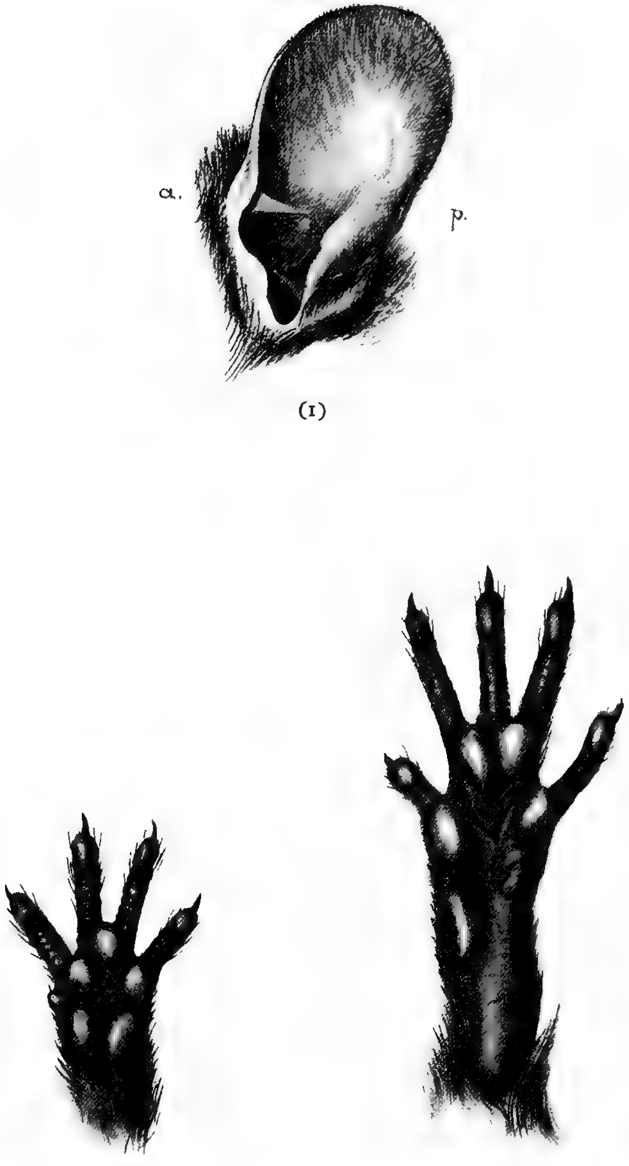
Within the last two centuries competition with the much larger and heavier Brown Rat (*E. norvegicus*) has almost completely eliminated the present species from the temperate countries of Europe, and from much of North America; here and there, however, in these regions colonies still manage to survive. In warmer countries more suited to its organisation, and where consequently it is not condemned to a purely parasitic existence, this species is well able to maintain its ground and is still the "common rat." At sea its lightness and superior skill as a climber give it a great advantage over its adversary, and even in temperate latitudes it is still, and is likely to remain, the principal "ship rat."

Distribution in time, and origin:—Judging from its wild distribution and history, this species is of Oriental origin, and the group must be of considerable antiquity in the East. The only fossil remains known, however, are some of perhaps rather questionable age found in the Pleistocene of Europe. Pictet (*Mém. Soc. Phys. et Hist. Nat.*, 1846, xi., 90) described remains, from the gravels of Mattegnin, Geneva, apparently not distinguishable from this species. A lower jaw from the Pleistocene of Lombardy was described by Cornalia (*Mamm. foss. de Lomb.*, 1858, 38), who named it *Mus rattus fossilis.* To this form Woldrich (*Sitzb. kais. Akad. Wiss., Wien., math.-nat. Cl.*, 84, Abt. l., 250, 1881; and 88, Abt. l., 1025, 1883) referred jaws from the fissure deposits of Zuzlawitz, Bohemia, and his figures indicate a species similar to *E. rattus.* No fossil remains have been discovered in Britain. If present in Europe during the Pleistocene, the species must have died out, and it was subsequently reintroduced as described above. Many bones were found among the pile-dwellings of Mecklenburg; these may indicate the presence of the species in Germany before the 13th century (for references see Brandt-Woldrich, *Mém. Ac. Imp. Sc., St Petersb.*, 35, 67).

Description:—*E. rattus* is smaller, much lighter, and more delicately built than the Brown Rat; its tail is usually longer, never noticeably shorter, than the head and body.

The head is slender, with a pointed snout. The naked muzzle-pad is small and has a deep median groove, which is continuous with the lip-cleft. The eyes are large, but not particularly prominent. The ears are of a broad ovate or rounded form; they are of considerable length (half that of the head), projecting conspicuously from the fur and reaching or covering the eyes when laid forward. Their substance is thin and translucent; the inner and outer surfaces finely papillose and thinly clad with short hairs. They are practically destitute of meatal valves, the posterior border of the meatus having but a barely indicated ridge. The hands and feet are of moderate size, long and narrow, and they are provided with small, simple claws, which are longest in the feet; the dorsal surfaces of the hands and feet are clothed with short stiff hairs, but the palms and soles are naked. The skin of each digit is folded in scaly, annular corrugations, of which nine or ten are present on the lower surface of digit 3 in the hand and foot; on the upper surface, where the corrugation is finer and less conspicuous, the grooves and ridges are about twice as numerous; the hairs clothing the upper surface of the digits rise principally from the grooves between the corrugations. In each hand the thumb is reduced to a mere tubercle bearing a vestigial nail which does not extend to its edge; digit 5 is

PLATE XXXII.



THE BLACK OR SHIP RAT (*Epimys rattus*).
(1) LEFT EAR; (2) LEFT HAND; (3) LEFT FOOT. (Twice life size.)

slightly shorter than 2; digits 3 and 4 are of about equal length and a little longer than digit 2. There are five large and distinct pads, but there is no free supplementary pad external to that at the base of digit 5. In each foot the hallux reaches to the middle of the first joint of digit 2; digit 5 is slightly longer, reaching the end of the first joint of digit 4; digits 2, 3, and 4 are the longest of the toes, and nearly equal to each other, 3 being the longest. There are six plantar tubercles; of these the postero-internal is more than twice as long as broad, and it is wider in front than behind; the postero-external pad is well developed, and fully one-third of the size of that at the base of digit 5; a small free supplementary pad is situated externally but close to the pad at the base of digit 5, but no similar pad is normally present in connection with the pad at the base of digit 1. The skin between the pads is wrinkled; elsewhere it is smooth. The tail is long, its length usually exceeding that of the head and body; it tapers distally, is somewhat square in transverse section and distinctly annulated throughout, there being about nine of the scaly rings in a length of 10 mm. near the middle; it is clothed with short, stiff hairs both above and below, and these rise from the distal edges of the scales. At the root of the tail the hairs are sparsely distributed and very short, their length being equal to the width of one annulation and a half only; distally they gradually become more numerous and longer, their length being equal to the width of at least three annulations, and these latter they partially or completely conceal. Posteriorly the hairs project slightly beyond the tip of the tail, but they do not form a true pencil. The tail is relatively longer in the young than in the adult; it is composed of thirty-seven or thirty-eight vertebræ (de l'Isle), and has from 250 to 260 annulations in all. There are ten mammæ in the females, arranged in two pectoral and three inguinal pairs. Occasionally supernumerary mammæ are developed in the pectoral region; in some cases an additional teat may be present externally to either the right or the left anterior pectoral mamma; in others an additional pair may be developed just in front of or just behind the normal posterior pectoral pair.

Pelage:—The longer whiskers are longer than the head and ears; the lower two or three are white, the others dusky. In addition two or more long cilia usually rise from the supra-orbital region.

The general covering of the body consists of three kinds of hairs in all rats; but these kinds intergrade with each other perfectly. Very abundant and fine, unicoloured or annulated hairs, which attain a length of about 7·5 mm., constitute the underfur. The middle hairs, 10 to 13 mm. long, are usually annulated, and the general coloration of the animal is largely dependent upon the hue of their subterminal bands; many of these hairs are coarse and grooved, and impart a somewhat harsh quality to the fur; on the back many of them are stiff, broad, flattened bristles, each with a distinct groove along its anterior or dorsal surface. In hot countries such hairs are in all rats frequently developed as spines. On the back, and particularly towards the rump, long black hairs, usually of from 20 to 25, but sometimes 30 or 40 mm. in length, occur; although these long hairs are a good deal more slender than many of the middle hairs, they also contribute towards producing a certain looseness and harshness in the appearance of the fur.

Colour:—The colour ranges from uniform dusky to brown, with a white or cream belly, and above it is usually darker along the dorsal line. Between the extremes every intermediate gradation may be found. These intermediates occur frequently in large towns or ports, where, owing to the cosmopolitan nature of the rat populations of such localities, much crossing probably takes place. In more open and remote districts the coloration conforms usually to one or more definite types, and intermediates are rare; for details, see below under Geographical variation.

Young:—The pelage of the young is relatively soft and full; all three kinds of hair can be distinguished in individuals with a head and body length of from 78 to 100 mm., but the bristles and long dorsal hairs in such specimens are relatively feeble and do not much exceed the underfur in length. In the "wild-coloured" races the coloration is generally like that of the adults, although the hue is duller and greyer. According to de l'Isle, the dusky (*r. rattus*) and the "wild-coloured" (*frugivorus*) races are distinguishable by colour ten days after birth.

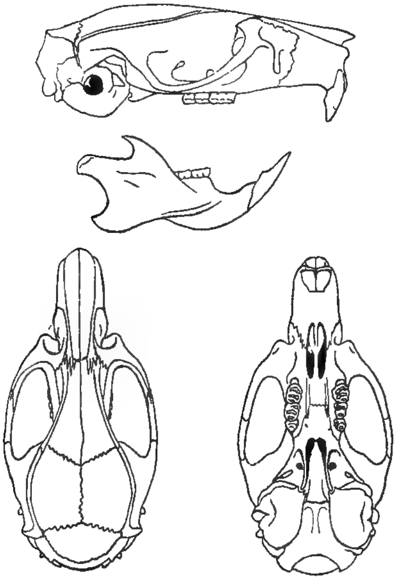


FIG. 90.—SKULL AND MANDIBLE OF *Epimys rattus* (life size). From Miller's *Catalogue of Mammals of Western Europe;* reproduced by the kind permission of the Trustees of the British Museum (Nat. Hist.).

The adult **skull** (Fig. 90) compared with that of *E. norvegicus* differs in its smaller size (condylo-basal length 38 to 45 mm., instead of 43·4, usually not less than 45, to 54·2 mm.) and lighter build. The brain-case is relatively slightly broader; the prominent supra-orbital ridges are continued backwards along the parietals, at a relatively low level, as outwardly curving (instead of approximately parallel) crests; the length of a parietal, measured along a crest, is considerably less than, instead of about equal to, the greatest distance between the crests. The parietals are vaulted noticeably above the general dorsal profile, a feature emphasised by a slight flattening of the frontal and inter-parietal regions. The large inter-parietal extends relatively far backwards, and its boldly convex posterior border produces a characteristic backward deflection (from the plane of the mastoid processes) of the central part of the lambdoidal crest; as a consequence the occiput is vertical, the condyles are completely hidden in the dorsal view, and the occipito-nasal length amounts to from 105 to 106·5, instead of 102 to 104·5 per cent. of the condylo-basal length. The rostrum is relatively slender; its width amounting to from 17·6 to 20·3, instead of 19·5 to 22·3 per cent. of the condylo-basal length; the blade-like outgrowths of the premaxillæ beneath the nasals are rather large; the zygomatic arches as a whole are more slender; and the palatal length and the diastemata (in *E. r. rattus*, *alexandrinus* and *frugivorus*) are relatively a little shorter than in the Brown Rat. The auditory bullæ are relatively a little larger and more inflated than in *norvegicus*, and they compress to some extent the anterior part of the basi-occipital, the width of the latter bone in front being rather less instead of slightly more than half its median length.

As in all other mammals, growth produces many changes in the proportions of the skull, the facial region being the chief seat of post-natal growth. The following measurements from Hossack illustrate the process in the present species:—

Extreme length.	Cranial breadth.	Inter-orbital breadth.	Length of zygomatic plate.	Diastema.	Upper molar series.	Length of nasals.
	Percentages.					
Young, 28 mm.=100 . .	50	19·6	8·9	25	25	33·9
Adult, 41·5 mm.=100 . .	37·4	13·9	12·4	27·5	17·1	35·7

Apart from its smaller size the **mandible** does not differ importantly from that of *norvegicus*.

The **cheek-teeth** (Plate XXVIII., Fig. 8) have the outer cusps slightly less reduced, and in the upper teeth, the median tubercles slightly less developed than in *norvegicus*. In m^1 cusp 1 is distinct and usually nearly as large as x; as a rule there is no trace at all of an anterior cingulum. In m^2 cusp 5 is still evident although partially fused with z; in one case Forsyth Major saw this cusp placed so far forwards that it blocked up the entrance to the transverse sulcus. In m^3 a minute trace of cusp 1 may be present occasionally, but 5 is completely lost. In m_1 cusp 6 is apparently a constant feature, but n is always more vestigial and may be wholly absent; m_3 appears to be rather more simplified than in *norvegicus*, but the posterior lobe when quite unworn shows distinct traces of cusps 4 and *y*.

Exceptional variation:—Individuals with a white chest spot, sometimes of very large size, or a median stripe of white, are not infrequent in *E. r. rattus*, and have been observed at Yarmouth by Patterson; similarly, individuals with a dusky patch or stripe are often found among the light-bellied forms. From the experimental breeding of *norvegicus* performed by Crampe, Doncaster, and Mudge, it would appear that such patterns are the subjects of Mendelian inheritance independently of the colour. A white-spotted *r. rattus*, from Kongsberg, Norway, has been recorded by Collett. Rarely, an ochraceous patch is seen on the ventral surface just behind either the right or the left fore limb (B.M., Nos. 1.11.3.26, Brazil, *alexandrinus;* 8.9.12.2, British New Guinea, *rattus;* both males). In some forms, particularly in the young, a white spot is present on the forehead: on such a variation from the Punjab, *Mus brahminicus* of Lloyd (*Rec. Indian Mus.*, iii., 1909, 22) is based; Fatio (p. 199) describes, from the neighbourhood of Geneva, a colony of Black Rats in which, young and old alike, all were characterised for many consecutive years by the presence of a conspicuous white lock on the centre of the forehead. Albino specimens have been known from the time of Gesner (see Kolazy, *Verh. Zool.-bot. Ges., Wien.*, 1871, 731, and below under *norvegicus*). According to Patterson (*Zoologist*, 1907, 69), a male from Yarmouth was of a very pale blue-white colour and had fiery red eyes; its creamy white tail was rather shorter than usual. As is the case with *norvegicus*, a hairless variety, due to disease, is known (T. E. Belcher, *Zoologist*, 1904, 72; and J. Woodward, *Field*, 19th August 1905, 378).

Bellermann[1] said that "very often six to eight lie together and entwine their tails as closely as if they were fused with each other. Such a nest is called a 'King Rat.'" Blasius (319), repeating this curious statement, apparently on his own authority, says that the tails *are* fused, and that as such individuals are incapable of moving freely in the search for food, they must be fed by their parents or by other rats; hence the name *Rattenkönig*.

Geographical variation:—This species is represented in the Oriental region by a great number of named forms, but the status of many of these is still far from being satisfactorily determined. Oldfield Thomas (*Proc. Zool. Soc.*, London, 1881, 533) arranged the Indian members of the group in three sub-groups or varieties; he used the name *alexandrinus* for all the Indian forms of *rattus*, and stated that the "typical form," characterised by its large size, long tail, and coloration (dark rufous grey above, white below), inhabited Kashmir and the whole north-western region of India.

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[1] *Daseyn des Rattenköniges*, 1820. Oken, *Allgem. Naturgesch.*, 7, Abt. 2, 719. A belief in "King Rats," dating at least from Gesner (*De Quadr.*, i., 829), is widely spread in Germany and in the German idiom, "*ein Rattenkönig von Unwahrscheinlichkeiten*"="a perfect maze of improbabilities" (see Muret-Sanders, *Encyclop. Wörterbuch*; J. and W. Grimm, *Deutsches Wörterbuch*, 1893). Schreber, long ago, dismissed this belief as "a mere and very badly contrived fable."

A somewhat similar arrangement was later adopted by Bonhote (*Fascic. Malay.*, Zool., i., 32, 1903; and *Proc. Zool. Soc.*, London, 1910, 653), who recognised three sub-groups of Oriental *rattus* as follows:—

(1) The **jalorensis** sub-group, of which *E. jalorensis*, Bonhote, from Jalor, Perak, and Siam, is the type. These are hill-rats representing the *nitidus* group of Thomas and other authors, and they have the hairs of the under parts white to their bases, and a hind foot length of about 30 mm. The sub-group has a wide but discontinuous distribution in India and Malaya.

(2) The **rufescens** sub-group, of which *E. rufescens*, Gray, from Dharwar, is the type. These are tree-rats, and have the hairs of the under parts with white or yellowish tips, and slate-coloured bases, and a hind foot length of about 33 mm. This sub-group is found throughout the whole of continental India, except the north-western part, and in Ceylon. In some provinces and in Ceylon a variety with a pure white belly is found side by side with typical *rufescens*, but in Burma and Tenasserim the white-bellied form alone occurs (Wroughton, *J. Bombay N. H. Soc.*, 23, 474 and 715). From Simla, Bonhote has described *E. vicerex*, a member of the group with striking bicoloration of the tail and white feet.

(3) The **griseiventer** sub-group, of which *E. griseiventer*, Bonhote, from Perak, is the type. These are chiefly house-rats, and in them the ventral hairs are either entirely slate-coloured or else have fulvous tips, and the hind foot measures about 35 mm. This sub-group has a wide distribution throughout India, Ceylon, and the Malay peninsula and islands.

Hossack (*Mem. Indian Museum*, i., 1-80, 1907) studied the rats of Calcutta in connection with plague; his material led him to regard the distinctions between the races of *rattus* recognised by Bonhote as quite inconstant and sporadic, and he therefore denied that such characters have any systematic importance. Bonhote (*Proc. Zool. Soc.*, London, 1910, 653), in answer to Hossack, states that in the large towns, whence all Hossack's material came, no order or classification is possible, because the varieties have become hopelessly mixed and crossed, but that in the country districts the varieties are much better defined, and apparently breed true; "all these varieties of the long-tailed rat belong to one species, *Mus rattus*." Meanwhile Lloyd (*Rec. Indian Museum*, iii., 1-100, 1909) studied a very large number of rats from India and Burma; his work was a continuation of that of Hossack, and was carried out from a biological and plague point of view; he likewise criticises the systematists, but in his paper many facts supporting the view that the "varieties" of *rattus* breed true in the country districts will be found; thus rats in large numbers were collected from sixty-nine villages in the Punjab, but white-bellied specimens were only found in three rather widely separated localities, two of them in the Amritsar district, and one in the Lahore district.

The Egyptian races of *rattus* have also been studied by Bonhote (*op. cit.*, 1910), who finds only two forms evident there, viz.:—

(1) *E. r. frugivorus*,[1] Rafinesque, with white under parts and light-coloured feet, the hind foot being usually 35 mm. long.

(2) *E. r. alexandrinus*, Geoffroy, with slate-grey under parts and dark feet, the hind foot being usually 33 mm. long.

Owing to the propinquity of forms, these races are in Egypt very much mixed up together, and in practice merely represent extremes of a varying series. Bonhote regards these two forms as the analogues of the Indian *rufescens* and *griseiventer* sub-groups; he finds by measurements that a third type, indistinguishable by colour, but with a hind foot of 29-30 mm., exists, and he suggests that this corresponds to the Indian *jalorensis* sub-group, but in Egypt no difference of habit is visible.

A recent examination of the material in the British Museum from all parts of the world other than the Oriental region, amounting to more than 200 specimens, showed that, adopting Bonhote's definitions, *frugivorus* could always be distinguished from *alexandrinus*; but some difficulty was found in separating the darker specimens of *alexandrinus* from the paler phases of *r. rattus*. Bonhote (1910) showed that when the hind foot measurements of a large number of individuals were plotted as curves, either for *frugivorus* or *alexandrinus* separately or for both races together, the curve in each case showed three apices, viz., at 35, 33, and 30 mm. In *frugivorus* the major apex for both sexes occurred at 35; in *alexandrinus* it occurred at 33 for males and at 35 for females; the minor apex at 30 was regarded as an indication of the latent presence of a representative of the Indian *jalorensis* group. The material in the British Museum similarly treated has given a similar result, save that for both sexes of *alexandrinus* the major apex occurs at 33 mm. Such facts appear to indicate, according to Bonhote, that the three forms are in each case mutations, indestructible and ready to develop whenever a suitable environment offers. The curve for *r. rattus* is, however, much more complex, since it shows for both sexes large apices at 34 and 36 and a smaller one at 38; for males minor apices occur at 30 and 32 mm.

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[1] Bonhote uses Savi's name *tectorum* for this form; "*tectorum*" is, however, antedated by *Musculus frugivorus*, Rafinesque.

Bonhote (*Proc. Zool. Soc.*, London, 1912, 6) found on crossing *frugivorus* with *alexandrinus* that the former was apparently a simple Mendelian dominant to the latter; and while the heterozygous *frugivorus* gave a proportion of pure *alexandrinus*, the latter always bred true. By the mating of *frugivorus* with *alexandrinus* thirty "hybrids," all being in appearance typical white-bellied *frugivorus*, were produced. Five pairs of these hybrids were mated, and their progeny consisted of 17 (apparent) *frugivorus*, 5 *alexandrinus*, 7 fawn *frugivorus*, and 1 fawn *alexandrinus*—the Mendelian expectation being 18, 6, 6, 2 for these respective kinds. The fawn types are novelties, arising probably from the absence from them of black pigment.

The classic experiments of de l'Isle, made shortly after, and unfortunately in ignorance of, Mendel's great discovery, seem to indicate that the dusky race *r. rattus* behaves in turn similarly as a dominant to *frugivorus*[1]; his results are, however, complex, and not easy to disentangle, probably because both *rattus* and *frugivorus* include a large percentage of heterozygous individuals. The hybrids of *rattus* × *frugivorus* on being paired together gave a progeny of numerous black rats, fewer *frugivorus*, and, as in the case of the cross *frugivorus* by *alexandrinus*, two novel types, viz., one relatively abundant, with light-coloured back and dark belly, called by de l'Isle the "semi-alexandrine"[2]; the other, much rarer, with dark back and white belly. The "semi-alexandrines" bred true. Morgan's experiments (*American Nat.*, xliii., 182, 1909) confirm in part these results deduced from de l'Isle's records; he found that whichever way the cross was made the progeny of *frugivorus* × *rattus* were black; in the first generation he raised thirty-two black individuals, but they showed some variation in the degree of their blackness. On pairing these hybrids, Morgan obtained a litter of four black and one grey, the blacks varying in shade as in the first generation; although the number bred is too small to yield any precise result, it indicates so far as it goes that the two colours follow Mendel's law.

It may be suggested that both *alexandrinus* and *frugivorus* have contributed to the formation of the black race, *r. rattus*, which has arisen, perhaps on many distinct occasions, in response to the exigencies of a new environment, namely, that afforded by an exclusively parasitic life in temperate Europe. The fact that the curve of the hind foot measurements shows a greater number of apices than does the hind foot curve of either of the two "wild" races is explicable on the assumption of such a multiple origin; further, *rattus* behaves certainly as a dominant to *frugivorus*, and is therefore in all probability dominant to *alexandrinus* as well; lastly, having regard to the present mixed condition of the two "wild" races in Egypt, it is probable that the first immigrants to western Europe from the Near East comprised representatives of both *frugivorus* and *alexandrinus*.

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[1] Although de l'Isle throughout his paper calls his light-coloured rat *alexandrinus*, his description of it as having the ventral hairs white to their bases leaves no room for doubting that his specimens were of the *frugivorus* race as defined by Bonhote.

[2] De l'Isle's "semi-alexandrine" corresponds apparently to *E. r. alexandrinus* as defined here.

In this work three[1] sub-species are described as British, viz., *E. rattus rattus*, Linnæus; *E. rattus alexandrinus*, Geoffroy; and *E. rattus frugivorus*, Rafinesque:—

(1.) THE BLACK RAT.

Epimys rattus rattus, Linnæus.

1758. MUS RATTUS, Carolus Linnæus, *Syst. Nat.*, 10th ed., 61, and 12th ed., 83, 1766; described from Upsala, Sweden; of most subsequent authors.

1800. M[US] R[ATTUS] ALBUS, ATER, CINEREUS, and MACULATUS, J. M. Bechstein, *Pennant's Allgem. Uebersicht d. vierfüss. Thiere*, ii., 494 and 713.

1833. MUS TECTORUM, var. FULIGINOSUS, Bonaparte, *Iconogr. Fauna Ital.*, i., fasc. 3, pl. xxii., fig. 1 (name on plate only); described from Italy.

1842. MUS SUBCÆRULEUS, Lesson, *Nouv. Tabl. du Règne Anim.*, *Mamm.*, 138; described from Rochefort, Charente-Inférieure, France.

1867. RATTUS DOMESTICUS, with the races FUSCUS, VARIUS, FULVASTER, ALBUS, and ATER, L. Fitzinger, *Sitzungsber. kais. Akad. Wiss. Wien.*, *math-nat.* Cl., lvi., (1) 64; described from Austria, Hungary, and Germany.

1902. MUS ALEXANDRINO-RATTUS, V. Fatio, *Revue Suisse de Zool.*, x., 402; described from Ticino, Switzerland (see Mottaz, *Bull. Soc. Zool. de Genève*, i., 163, 1908).

1905. MUS RATTUS RATTUS, J. G. Millais, *Zoologist*, June, 204; *M.* (*Epimys*) *rattus*, Trouessart.

1905. MUS RATTUS ATER, J. G. Millais, *Zoologist*, June, 205; described from London, England; type a male, No. 5.7.28.1 of British Museum collection; *M.* (*Epimys*) *rattus ater*, Trouessart.

1908. EPIMYS RATTUS, Satunin, *Mitth. Kauk. Mus.*, Tiflis, iv. Lief. 1-2, 112.

1912. EPIMYS RATTUS RATTUS, G. S. Miller; *Catalogue*, 853.

The Black Rat has figured in books as *Glis* (Jonston, *Quadr.*, 114, 1657) and *Sorex* (Hoefnagel, *Archetypa*, 3, tab. iii., 1592). Gesner mentions it (*Quadr.*, 731, 1551) as "*Mus domesticus major, quem vulgo rattum vocant*"; it is "*Mus Major seu Sorex*" in Merrett (*Pinax*, 167,

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[1] The decision to regard *E. r. frugivorus* as distinct from *alexandrinus* has been reached since the key on p. 377 was drawn up; clause A of the section dealing with *E. rattus* should read:—

(A) Upper side brownish.

(*a*) Ventral hairs white to bases (*E. rattus frugivorus*).
(*b*) Ventral hairs with slaty bases (*E. rattus alexandrinus*).

1667); "*Mus domesticus major, sive Rattus*, the Rat" in Ray (*Syn. Quadr.*, 217, 1683), Sibbald (*Scot.*, 12, 1684), and Pennant (*Brit. Zool.*, ed. ii., 97, 1768); "*Mus rattus domesticus*" of Klein (*Quadr. disp.*, 57, 1751); and "*Mus* (*Rattus*) *cauda longissima, obscure cinereus*," in Brisson (*Quadr.*, 168, n. 1, 1762) and Gronovius (*Zooph.*, 4, n. 18). "*Mus rattus*" of Albertus Magnus (*de Anim.*, lib. xxii., 182, *circa* 1250) has been shown by de l'Isle to have been a dormouse (*Eliomys quercinus*).

The **synonymy** is that of the species and typical sub-species. It is perhaps to be regretted that in this case we are forced to regard as the typical form something which is apparently no better than an undesired product of domestication.

The **history**, **origin**, and **status** of this sub-species have been discussed above under the species (see headings *History*, *Distribution*, and *Geographical variation*).

Distribution:—Primarily the whole of temperate western and central Europe, from Ireland eastwards, and from central France and northern Italy northwards to central Sweden. Throughout this region its numbers have greatly diminished since the introduction of *E. norvegicus*, and over great tracts it has become quite extinct.

In Norway the original stock survived recently only at Kongsberg, but it is now dying out or else is extinct there. Although formerly common it was probably never so numerous in that country as *norvegicus* subsequently became. As a reintroduction a colony has established itself in the Oslo Havn at Christiania, and from time to time the animal, as in other countries, makes a transitory appearance in the various seaports. All Norwegian specimens belong to the present sub-species. In Sweden it survives in decreasing numbers from Skåne northwards to the centre of the country. In Denmark, though practically ousted by the Brown Rat in the course of the nineteenth century, it is still found occasionally, possibly as a re-introduction, in Copenhagen (Winge).

In Germany it was abundant about 1835; Blasius describes it as keeping entire towns to itself, and then, as the Brown Rat advanced, its domain dwindled to districts, streets, and, finally, individual houses. Dead specimens could often then be seen in the gutters of Berlin, and about ten years earlier, in those of Rhineland towns. By 1857 the species had become rare, and by 1879 very rare (Meyer, *Nature*, 8th and 29th May 1879). In Münsterland it is said, however, to have occurred commonly in 1883, in places where only the Brown Rat was found before, and in Greitz it appeared to be increasing at the expense of that species (P. Magnus, *Sitz.-B. nat. Freunde, Berlin*, 1883, 47); but possibly there is confusion with *hibernicus* here.

In France and northern Italy it is now uncommon. Gadeau de

Kerville (p. 173) describes it as being still very common in the country districts of Normandy, but as rather rare in the towns and those localities in which the Brown Rat is abundant; probably many of the Norman Black Rats belong, however, to the "wild-coloured" sub-species. In Switzerland, according to Fatio, it survived in 1869 at Geneva, where the Brown Rat had scarcely then attained a footing; the present sub-species and the "wild-coloured" forms were there equally abundant.

In **Britain** it was formerly widely spread both on the mainland and the islands. It is still occasionally met with in old houses in remote districts, but probably the only remaining mainland colony of any size is that at Great Yarmouth, Norfolk, studied by Patterson; further details of this are given above under the species (History). Other colonies are found in the Channel Islands, notably on Sark; perhaps in Scilly; on Lundy; in the Orkneys, on South Ronaldshay; and perhaps in the Hebrides, on Benbecula.

In **Ireland** it is now extremely rare; the only colony of "native" Black Rats reported in quite recent times is that at Dungarvon, Co. Waterford, alluded to above under History of species.

This sub-species has been carried by shipping from Europe to all parts of the world. Its introduction to South and Central America dates from the sixteenth century; Pennant (citing Garcilasso de la Vega, 384. Ovalle, *Churchill's Coll.*, iii., 44) says this happened about the year 1544, in the time of Viceroy Blasco Nunnez. The date of its introduction to North America is uncertain, but it was well established in the British colonies there in the beginning of the eighteenth century. Since the arrival of *E. norvegicus* its numbers have decreased, and it is now rare in most parts of the United States and Canada; it is now found in scattered colonies mostly east of the Mississippi valley, and on certain islands along the coast on both sides of the Continent. In parts of Central and South America it has been more persistent and is still abundant (D. E. Lantz, 11). It has acquired a wide distribution in Africa and Australasia. As an introduction to Indian ports it has succeeded in returning to the probable home of its ancestors; its success as a colonist varies, however, in different localities, for while Liston estimated (1905) it to form about 30 per cent. of all the rats of Bombay, Hossack found it very rare in Calcutta.

Description:—The general **colour** is slaty, darker on the back, paler below. The dorsal fur is long, black, and silky, and often shows in certain lights a greenish metallic lustre; the underfur and long dorsal hairs have slaty bases and black tips; intermixed with them are more or less numerous whitish hairs and bristles. On the under parts the fur is short and of a uniform slaty or light leaden hue. There is sometimes a chest-spot or stripe of white; more rarely a white spot may be present on the forehead, and there may be some white on the feet.

The **young** have the fur softer, and their backs are of a richer and more lustrous black than in the adults; these features are chiefly due to the feeble development or absence of the whitish bristles.

Geographical variation:—Specimens brought from Black Sea ports to London were described by Millais as a distinct sub-species, *E. r. ater;* this was said to differ from true *rattus* in its deeper and richer pelage, its glossy black back, which presented a curious green sheen in a bright light, white or grey hair-bases, and slightly longer tail. Similar specimens were recorded by Millais from the Black Sea ports, Crimea, and various parts of Africa, and he states this variety to be the only one met with in the Transvaal. Miller does not distinguish this form from *r. rattus.* We have examined the type, an old male, together with specimens in the British Museum from Deelfontein, and as a result are inclined to adopt Miller's view. Nevertheless, there is probably some foundation for Millais' sub-species, since *r. rattus* may have developed independently in various parts of Europe at various times from quite different "wild-coloured" invading stocks. It may be added that, like all its relatives, this sub-species shows a tendency to develop races adjusted to the needs of purely local conditions. It is difficult to see where true *rattus* now exists, except perhaps in such localities as Sark and the Orkneys (South Ronaldshay).[1]

(2.) THE ALEXANDRINE RAT.

Epimys rattus alexandrinus, Geoffroy.

1803. MUS ALEXANDRINUS, I. Geoffroy St Hilaire, *Cat. Mammif. du Mus. Nat. d'Hist. Nat.*, Paris, 192; *Descr. de l'Égypte, Hist. Nat.*, ii., 733, Atlas, pl. v., fig. 1, 1812; described from Alexandria, Egypt; Savi; in part of de Selys-Longchamps and Blasius.

1905. MUS RATTUS ALEXANDRINUS, J. L. Bonhote, *Proc. Zool. Soc.*, London, 1909, 794, and 1910, 654.

1910. MUS (EPIMYS) RATTUS ALEXANDRINUS, E. L. Trouessart, *Faune des Mammif. d'Europe*, 144 (in part).

1912. EPIMYS RATTUS ALEXANDRINUS, G. S. Miller, *Cat. Mamm. West Europe*, 854 (in part).

As suggested long ago by Savi (*Nuovo Giorn. de'Letterati*, Pisa, x., 74, 1825), in defining his *Mus tectorum*, the name *alexandrinus* should be restricted to the sub-species figured by Geoffroy in 1812 (*loc. cit., sup.*),

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[1] "Black and Alexandrine Rats" were taken in 1890 on a Leith steamer; the wild-coloured forms are abundant on some Scotch coasting vessels (W. Eagle Clarke, *Scott. Nat.*, 1891, 36, and W. Evans, *Supplement*).

i.e., to the form with brown back and dusky belly; this course has been adopted recently by Bonhote.[1]

Distribution:—Described from Egypt, where it is a house rat, the present sub-species inhabits much of North Africa; eastwards it ranges throughout Arabia and Palestine to India, where to the south and east it seems to be represented or replaced by the typical dark-bellied form of *E. rufescens.* It occurs in the regions around the Caspian and Black Seas, and we are informed by Andersen that all the specimens he collected in Bulgaria were of this type. The great majority of the Iberian specimens before us, and some from southern France (Biarritz), belong to this form.

In central and northern Europe it is no doubt occasionally introduced, but it does not appear to succeed in establishing colonies of any importance. No specimens of either "wild-coloured" sub-species have ever been obtained in Norway; but in the port of Copenhagen "brown-backed" specimens have appeared recently (Winge).

In **Britain** it is frequently introduced from shipping, but many of the published records of its occurrence refer to the next sub-species; it is not always easy or possible, however, to determine from the descriptions given which of the two sub-species is in question. Coward obtained *E. r. alexandrinus* in company with the two other sub-species and *norvegicus* upon Lundy, and apparently those seen by Millais on Whalsey, Shetland (see p. 585), were also referable to the present form.

In recent times it has been dispersed by commerce throughout many parts of Africa south of the Sahara; many specimens from this region are in the National collection, and some of them are so dark that it is not always easy to distinguish them from *E. r. rattus.* From America we have seen only two specimens—one from the Orinoco, the other from Brazil (Minas).

Description:—*E. r. alexandrinus* is indistinguishable from *E. r. rattus*, or the next sub-species, except by its coloration. The upper parts vary in colour between some shade of yellowish-brown and light grey; along the middle of the back black hairs are present in variable abundance, and to them is due the appearance of dorsal darkening frequently seen. The hairs of the ventral surface have slaty or dusky bases; in some specimens the tips of these hairs are dusky also, so that the belly is as dark as the flanks, or even as the back; in others the ventral hair-tips are yellow, cream, or white in colour, the belly being then slightly lighter than the flanks in general colour. The line of demarcation along each flank is never sharply defined, and is frequently not apparent at all. The feet are brown above, with or without dusky markings.

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[1] See also Anderson, *Zool. of Egypt* (Mamm.), 1902, 274, and Bate, *Proc. Zool. Soc.*, London, 1904, 346.

Status:—The status of this sub-species has been discussed above under the species. The *semi-alexandrines* which appeared in the course of de l'Isle's breeding experiments (see p. 595) seem to represent this form, which may have arisen in the first place as a Mendelian mutation. By most writers it is considered as a mere intermediate between true *rattus* and the next sub-species, and it is the principal foundation of the statement, commonly found in books, that all intermediate stages can be found between the two extremes. As already mentioned, we have found occasional difficulty in separating dark specimens from true *rattus*, but we have not experienced any in distinguishing *alexandrinus* from *frugivorus*.

(3.) THE TREE OR ROOF RAT.

Epimys rattus frugivorus, Rafinesque.

1814. MUSCULUS FRUGIVORUS, C. S. Rafinesque-Schmaltz, *Precis des Découv. et Trav. Somiologiques*, 13; described from Sicily.

1825. MUS TECTORUM, G. Savi, *Nuovo Giorn. de'Letterati*, Pisa, x., 74; described from Pisa, Italy.

1827. MYOXUS SICULÆ, Lesson, *Man. de Micromamm.*, 274 (substitute for *Musculus frugivorus*, Rafinesque).

1839. MUS ALEXANDRINUS, E. de Selys-Longchamps, *Études de Micromamm.*, 54 (in part); Blasius (in part); de l'Isle.

1841. MUS SYLVESTRIS, Pictet, *Mém. Soc. Phys. et d'Hist. Nat., Génève*, ix., 153; described from near Geneva, Switzerland (the name an alternative for *leucogaster*, Pictet).

1841. MUS LEUCOGASTER, Pictet, *op. cit.*, 154.

1841. MUS NEMORALIS, E. de Selys-Longchamps, *Atti della seconda Riunione degli Scienziati Ital., Torino*, 1840, 247 (an accidental substitute for *sylvestris*, Pictet).

1845. MUS PICTETI, Schinz, *Synops. Mamm.*, ii., 142 (substitute for *leucogaster*, Pictet).

1905. MUS RATTUS ALEXANDRINUS, J. G. Millais, *Mamm. of Great Britain*, ii., 205 (in part); (sub-genus *Epimys*) Trouessart (in part).

1909. MUS RATTUS TECTORUM, J. L. Bonhote, *Proc. Zool. Soc.*, London, 1909, 794, and 1910, 652.

1912. EPIMYS RATTUS ALEXANDRINUS, G. S. Miller, *Cat. Mamm. West. Europe*, 854 (in part).

Synonymy:—The present form, differing widely in appearance from *E. r. rattus*, has naturally attracted far more attention than the other wild-coloured sub-species, *E. r. alexandrinus*. By most recent writers it has been confounded with *alexandrinus*, but, as shown above, the latter name must be restricted to the form which, having a dusky belly, has been regarded generally as a mere gradation between the present sub-species and typical *rattus*. Savi's well-known name, *tectorum*, is clearly antedated by Rafinesque's *frugivorus*, and must therefore give place to the latter.

Local name:—*Topo tettajolo* in Tuscany.

Distribution and status:—*E. r. frugivorus* is the common rat of the Mediterranean region and North Africa. Northwards it ranges throughout Italy into southern Switzerland. In France it is known from the south (Var), and it occurs also in Brittany and Normandy (de l'Isle). In Iberia *alexandrinus* appears to be the prevalent form, but we have seen specimens of *frugivorus* from Jerez, Cadiz. It is found on most of the Mediterranean islands;[1] in Greece, Montenegro, and Asia Minor; and it also occurs on the island of Sokotra. On the more remote islands, at least, it breeds quite true to type, and in the warmer parts of its range it leads an outdoor life, often inhabiting and nesting in trees in situations remote from human dwellings; in these warmer districts it does not tend to be replaced by *norvegicus*.

In **Britain** it not infrequently makes an appearance in the ports. As authentic instances of this kind, may be cited one captured at Sunderland (*Field*, 26th Jan. 1889, 126; B.M., 89.1.28.1); another taken on board ship at Liverpool (B.M., 6.10.25.1); and a specimen with pale lemon belly found by Patterson at Yarmouth. A good many were obtained by Coward on Lundy, where the two other sub-species and *norvegicus* were also found.

It is often found on ships, and has been carried by them to all parts of the world; in the warmer countries it not infrequently succeeds in establishing itself as a colonist, resuming at the same time, in many cases, a free outdoor existence. The British Museum collection contains many examples of such "colonial" *frugivorus* collected in tropical South America, Madagascar, Australia, and Tasmania.

Description:—*E. r. frugivorus* agrees in all characters, save those of pelage and colour, with typical *rattus*. The fur is often remarkable for its length, density, and softness. The upper parts are light grey or brown, brightening sometimes to russet, and darkened along the middle line of the back to a greater or less extent by long black hairs. The under parts are pure white or pale yellow in colour, the ventral hairs being light-coloured to their roots; sometimes a patch of bright orange hue is present upon the throat or chest. The line of demarcation is always regular and sharply defined along each flank. The feet are usually white above, but they are sometimes washed with light yellowish-brown.

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[1] Rafinesque (*loc. cit.*) describes the Sicilian animal as living on fruit and nesting in the trees; he adds that it is edible—a circumstance which caused Lesson to refer the animal, with some hesitation, to the genus *Myoxus*. In the Balearic Islands, Thomas (*Proc. Zool. Soc.*, London, 1901, i., 42) found it "living a wild natural life, away from the houses," and he thought it "probably perfectly indigenous in the islands."

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
Sexually Immature of Both Sexes:—					
Epimys rattus rattus:—					
1. Yarmouth, Norfolk, male, 7th March 1896 (Barrett-Hamilton, from Patterson)	93	117	28	18	..
2. Waterford, Ireland, female, 2nd June 1889 (W. Eagle Clarke)	94	135	31·7	17·8	..
Sexually Mature Males:—					
E. rattus rattus:—					
1. Sark, Channel Islands, 7th Sept. 1912 (B.M., 12.10.1.1) .	195	220	36	24	..
2. Guernsey, Channel Islands	214	252	38	25·5	..
3. London, S.E. (W. Eagle Clarke)	173	198	34 [1]	25	..
4. Do. (Type of *M. r. ater*, Millais)	210	235	36	..	..
5. Rhum (on board ship), 3rd June 1913 (D. Anderson) . .	173	214	35	21	..
6. South Ronaldshay, Orkney, 13th November 1905 (W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1906, 49)	179	204	34·5	24	149·5
7. Belfast, Ireland, 24th Sept. 1889 (R. L. Patterson, per W. Eagle Clarke)	165	188	35·6 [1]	28·4	..
8. Do. 13th Feb. 1894	180	197	35·6	23·4	194·1
9. Do. do.	176	206	37·3	26·7	204·8
10. Do. do.	188	224	38·6	25·9	215·3
E. rattus alexandrinus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) . . .	206	229	38·1 [1]	25·4	..
2. Lundy Island, 31st Aug. 1907 (Coward, B.M., 7.12.19.2) .	209	233	40	25·5	..
3. Egypt, largest measured by Bonhote	199	220	35	26	..
E. rattus frugivorus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) . . .	170	206	38·1 [1]	25·4	..
2. Liverpool (ship), 24th May 1905 (B.M., 6.10.25.1) . .	228	230	37	..	..
3. Lundy Island, 1st Sept. 1907 (Coward, B.M., 7.12.19.4) .	199	234	37	25	..
4. Egypt, largest measured by Bonhote	188	232	35·5	24	..
Sexually Mature Females:—					
E. rattus rattus:—					
1. Yarmouth, Norfolk, 7th March 1896 (Barrett-Hamilton, ex Patterson)	148	171	31	21	..
2. Do. ? sex, Feb. 1896	143	192	..	..	..
3. Do. do. do.	178	213	..	..	..
4. Do. albino, 28th Jan. 1907 (Patterson, *Zoologist*, 69)	152	140	..	..	..
5. South Ronaldshay, Orkney, 19th Oct. 1905 (R. Godfrey, W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1906, 49) . .	156	196	35	23	..
6. Do. (J. M. B. Taylor, *Journ. cit.*, 1900, 181) . .	191	..	..	..	207·3
7. Belfast, Ireland, 24th Sept. 1889 (R. L. Patterson per W. Eagle Clarke)	178	207	36 [1]	25·4	..
8. Do. do. 13th Feb. 1894	173	208	35	..	190·2
9. Do. do. do.	176	207	36·9	24·1	185·7
10. Do. do. do.	170	199	35·8	24	139·4
11. Do. do. do.	187	206	38·4	25·4	215·5
E. rattus alexandrinus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) [2] . . .	183	236	38·1	26·7	..
2. Egypt, largest measured by Bonhote	195	208	35	26	..
E. rattus frugivorus:—					
1. Leith (ship), 20th Aug. 1889 (W. Eagle Clarke) [3] . . .	178	213	35·6 [1]	25·4	..
2. Lundy Island, 31st Aug. 1907 (Coward, B.M., 7.12.19.6) .	167	201	36	22	..
3. Do. do. (Coward, B.M., 7.12.19.3) .	177	196 [4]	38	22	..
4. Do. 29th Aug. 1907 (Coward, B.M., 7.12.19.5) .	198	227	36	24	..
5. Egypt, largest measured by Bonhote	190	232	36·5	24	..

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[1] With claws.

[2] Under-surface said by Mr Eagle Clarke to be of same colour as the back.

[3] Under-surface described in Mr Eagle Clarke's notes as creamy white.

[4] Tip broken.

Remarks :—The following measurements from Hossack (*op. cit.*, 9) illustrate the changes of bodily proportions which transpire with growth :—

	Head and body.	Percentages of head and body length.		
		Tail.	Hind foot.	Ear.
E. rattus, juvenile	95 = 100	147·3	31·5	18·9
Do. do. . . .	100 = 100	145	29	19
Do. do. .	105 = 100	128·5	27·6	16·1
Do. adult . .	173 = 100	121	19·1	12·1

Weight :—Two captive male *alexandrinus* (or *frugivorus*) weighed 4 and 5 ounces, or 113·3 and 141·6 grammes respectively; a female *E. r. rattus* in captivity weighed 5·25 ounces, or 148·5 grammes (Millais, ii., 208). The weights recorded by Eagle Clarke vary between 139·4 and 215·5 grammes, but as will be seen from the above table these weights are not those of the largest individuals enumerated. It is, however, improbable that the weight ever much exceeds 300 grammes; full-grown specimens of *norvegicus* frequently weigh from 450 to over 500 grammes. This great difference fully explains the inability of *rattus* to withstand its rival.

Skull :—Condylo-basal length, 38 to 45; zygomatic breadth, 19·2 to 22; interorbital constriction, 5·8 to 6·4; occipital breadth, 15 to 17·2; depth of brain-case at middle, 10·8 to 12·6; length of nasals, 14 to 17; of diastema, 10·2 to 13; of mandible, 23·2 to 28; of maxillary tooth-row, 6·4 to 7·4; of mandibular tooth-row, 6·2 to 7·2.

Distinguishing characters :—All the sub-species of *E. rattus* are best distinguished from all forms of *norvegicus* by their lightness, elegant build, longer tails, and larger and much more delicate ears. The adult skull has larger bullæ, and presents well-marked distinctions in the parietal and interparietal regions, as described above.

Habits :—A general account of the habits of rats is given below under *E. norvegicus.* The Black Rat is essentially a climber,[1] and does not burrow under houses or infest drains like its rival; it shows no liking for water, which it perhaps only enters occasionally, as when danger presses. As compared with the Brown Rat, it is doubtless in the main a clean feeder—possibly evidence of its more salubrious station rather than of a nicer or daintier palate. Lataste (313) says that it is by no means mute. Observers differ as to its odour, for while de l'Isle (184) describes it as more odorous and fetid than *norvegicus*, Adams (MS.) states it to be without the offensive smell of the latter species.

According to Shipley,[2] this species does not breed before it has attained a weight of at least 70 grammes. De l'Isle found it sexually mature before the age of three months, apparently full grown at four months, and that it did not live for more than two years, the old ones being infertile. Thirteen kept at the Zoological Gardens had an average longevity of seventeen months, the maximum being forty-one months.[1]

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[1] Hossack describes it as scampering upside down along the cage wires.

[2] *Journ. Econ. Biol.*, iii., 1908, 62.

De l'Isle found the period of gestation to be between twenty-three and twenty-four days; Bonhote (*in lit.*) finds it shorter—from twenty to twenty-one days. From two to four litters are born annually, the number of young per litter ranging between four and eleven. During the hot months in India,[2] and probably in other countries also, the percentage of young present in the whole rat population increases.

The young are born naked, except for the whiskers, which are visible with a lens (de l'Isle, 230), and pink; their eyes and ears closed; the length of the head and body at birth is about 50 mm., while the tail measures only about a third of that amount. At the fifth day the whiskers reach to the eyes, a feeble down covers the body, and the tail is about half as long as the head and body. On the tenth day the pelage shows colour, the whiskers reach to the ears, the latter still being only little "tags" (Hossack). On the eleventh day the eyes are open but feeble; the young are now clumsy, able to walk but not to run. At the eighteenth day the molars are still hidden within the gums, and the aliment is almost entirely milk. At the twentieth day the rat can run well; it is outwardly completely developed except in size and tail. At the twenty-first day the front pairs of molars are cut, but three-fourths of the aliment is still milk; on the twenty-fourth day eight molars are in place, and milk forms only about one-fourth of the aliment, the young being weaned about the twenty-seventh day. By the fortieth day all the cheek-teeth are cut (de l'Isle).

2. THE BROWN OR COMMON RAT.

EPIMYS NORVEGICUS, Berkenhout.

1769. MUS NORVEGICUS, J. Berkenhout, *Outlines Nat. Hist. Great Britain and Ireland*, i., 5, described from Great Britain; 1777, Erxleben, *Syst. Regn. Animal.*, i., 381, gen. 37, described from Norway; Rehn, *Proc. Biol. Soc.*, Washington, xiii., 167, 31st Oct. 1900; Collett, *Norges Pattedyr*, 180, 1911.

1772. MUS AQUATICUS, J. Rutty, *Nat. Hist. of the County of Dublin*, i., 281; a confusion with *Arvicola amphibius*.

1777. RATTUS MIGRANS, Zimmermann, *Spec. Zool. Geogr. Quad.*, 345.

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[1] P. Chalmers Mitchell, *Proc. Zool. Soc.*, London, 1911, 448.

[2] *Etiology and Epidemiology of Plague* (Calcutta, 1908), 9.

1778. MUS DECUMANUS, P. S. Pallas, *Nov. Spec. Quad. e. Glir.*, 91; described from Europe; of Gmelin and most subsequent authors.

1779. M(US) SURMOLOTTUS, Severinus, *Tentamen Zool. Hungaricæ*, 73; described from Central Europe.

1800. M(US) D(ECUMANUS) HYBRIDES, J. M. Bechstein, *Pennant's Allgem. Uebersicht d. vierfüss. Thiere*, ii., 713; described on p. 497; based upon a melanistic specimen for Waltershausen, Germany.

1800. MUS AMPHIBIUS, J. Landt, *Forsög til en Beskrivelse over Færöerne*, Kjöbenhavn, p. 238; Færoes.

1808. MUS FOSSOR, Walker, *Essays*, 497.

1816. MUS CASPIUS, Oken., *Lehrb. d. Naturgesch.*, iii., pt. 2, 895; an alternative for *decumanus.*

1837. MUS HIBERNICUS, W. Thompson, *Proc. Zool. Soc.*, London, 52; based upon melanistic specimens from Rathfriland, Co. Down, Ireland, *Nat. Hist. Ireland*, iv., 16, 1856.

1908. EPIMYS NORWEGICUS, Satunin, *Mitth. Kauk. Mus.*, Tiflis, iv., Lief. 1-2, 111.

1910. MUS (EPIMYS) NORVEGICUS and M. (E.) NORVEGICUS HIBERNICUS, E. L. Trouessart, *Faune Mamm. d'Europe*, 142.

1912. EPIMYS NORVEGICUS, G. S. Miller, *Cat. Mamm. West. Europe*, 858.

Le surmulot of the French (*rat* being the generic name); *die Wanderratte* of the Germans.

The **synonymy** given above relates to the Brown or Common Rat in Europe. Specimens from other parts of the world, *e.g.*, India, have received further names, but these do not require consideration in the present work. Up to 1900 practically all writers used Pallas's name *decumanus* (1778) for this species; but Rehn (*loc. cit. supra*) pointed out that Erxleben's *norvegicus* (1777) must supersede *decumanus.* The name *norvegicus*, however, dates from Berkenhout (1769), and since his description was based ostensibly on British specimens, the type locality is technically Britain and not Norway. As a name, *norvegicus* is a complete misnomer, since the species is no more than a modern introduction in Norway, as also in Britain; moreover, many of the pre-Linnæan writers, such as Ray, used "*Mus norvegicus*" (the spelling subject to variation) as the name of the Norwegian Lemming. Such objections, however, have no force technically, and on the ground of the rule of priority, applied only to Linnæan writings, *norvegicus* must stand as the trivial name of the present species.

Terminology:—This is the "Norway Rat" of Pennant (*Brit. Zool.*, i., 115), Berkenhout (1769), Shaw, and Turton; the "Brown Rat" of Pennant (*Quad.*, ed. 3, 1793, ii., 178) and most subsequent writers, although some, like Bingley and Bell, retain "Norway Rat" as an alternative name. Other names, which are or have been occasionally used for it, are "Wharf Rat," "Barn Rat," "House Rat," "Gray Rat," "Water Rat," and "Hanoverian Rat" (for origin of which last, see below under History). It is now generally known as the

"Common Rat," the name adopted here as being free from ambiguity (see p. 579).

Sex names:—*Buck* and *doe*; *dog* and *bitch* (occasionally); and *boar* and *sow* (amongst fanciers).

Local names:—"*Ratten*" or "*rotten*" of parts of Yorkshire and Scotland (E. R. Alston).[1]

Distribution and history:—The Common Rat is undoubtedly an Asiatic species, and has found its way to Europe only within the last two centuries. What precise part of Asia is to be regarded as its original home, has been the subject of considerable controversy. Pallas did not find it in Siberia, and Gmelin erroneously[2] claimed to have discovered it, inhabiting burrows in the fields in considerable numbers in Persia. Pennant, reflecting on these facts, and having heard of the Indian Bandicoots and their habits, conjectured that it had been brought from Persia and the East Indies to Western Europe by shipping. This view was maintained by many subsequent writers, and in 1852 Frank Buckland (*Curiosities Nat. Hist.*, i., 62) said:—"It is now agreed by most naturalists that it is a native of India and Persia; that it spread onwards into European Russia, and was thence transferred by merchant ships to England and elsewhere."

When, however, the mammals of India came to receive serious attention it soon became evident that this species was not a native of that country, it being met with only in the neighbourhood of certain ports; and Blyth was led to "suspect that the Trans-Baikalian region of East Asia had at least as good a claim to the *discredit* of originating the abominable brown rat as any other." Blanford, finding the species to be at present unknown in Persia, and to occur in India only along the coast and navigable rivers, arrived at much the same conclusion; he thought that Chinese Mongolia might with more likelihood be looked upon as its centre of dispersal. In China several short-tailed species, of smaller size but more or less closely resembling *norvegicus* in colour, occur. Thomas, receiving what purported to be a specimen of one of these, viz., *E. humiliatus*, Milne-Edwardes, was led to suggest this species as the possible wild stock of *norvegicus* (*Proc. Zool. Soc.*, 1898, 772); this specimen had, however, been incorrectly determined in Paris, and was in fact *norvegicus*, which is not uncommon in many parts of China (Bonhote, *Proc. cit.*, 1905, 393).

Kastchenko (*Ann. Mus. Zool. Acad. Imp. Sci. St. Petersb.*, xvii., 1912, 370) has described a wild form, his *E. norvegicus primarius*, inhabiting the region west of Lake Baikal, thus confirming Blyth's suggestion noted above; the westward range of this form extends through Irkutsk between latitudes 53° and 59° N., to Jenisseisk and Krasnojarsk, near the meridian of 90° E. The Asiatic range of typical *norvegicus*, according to Kastchenko, extends northwards from the shores of the Caspian Sea from about 47° to about 59° N. latitude, and eastwards almost to Tobolsk, near the meridian of 70° E. In the region between 70° and 90° E. longitude, and the whole width of Asia north of 60° N. latitude, there is no wild representative of the species—a fact in accord with the experiences of Pallas and Middendorff. This discontinuity of distribution may perhaps be regarded as proof of the ancient standing of *E. norvegicus* in Asia.

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[1] "When I was a boy, in the vicinity of Edinburgh, it was considered no mean feat to be able to say rapidly and correctly the words, '*A rotten loupit o'er a rope*; *loup, rotten, loup*,' and go on repeating them" (W. Evans, MS.).

[2] The rats found by Gmelin were probably "wild-coloured" forms of *E. rattus*.

It is possible that *E. norvegicus* was known to the ancients because, as suggested by Pennant and more recently by Blasius, the "*Mures Caspii*" described by Ælian (*Anim.*, 47) as "little less than Ichneumons, making periodical visits in infinite multitudes to the countries bordering the Caspian Sea and swimming boldly over the rivers holding by one another's tails," may have been of this species; these were referred to by Gesner under the name *Mus aquatilis.*

The species first appeared in Europe in the beginning of the eighteenth century, and it came both by land and sea. Pallas records that in 1727, which was a "mouse year" in the Caspian region, vast hordes of these rats migrated westwards after an earthquake; they swam across the Volga, the bed of the river being choked with them, and entered the houses of Astrakan in such numbers that nothing could be preserved from them. From Astrakan the species gradually spread westwards across Russia to the Baltic; according to Bujak (quoted by Blasius) it did not reach East Prussia before 1750, but Zimmermann speaks of it as common in Brunswick in 1780.

The earliest records of its arrival in Western Europe by sea are provided apparently by the memoranda (cited recently by Winge, *Danmarks Pattedyr*, 1908, 87) written in 1755 by Amtmand Urne of Bornholm, and now preserved in the Zoological Museum of Copenhagen. Urne states that he had heard that these rats arrived at Copenhagen with the Russian fleet, which visited that city in 1716; he records that they landed about 1725 from stranded Russian ships at Svaneke on Bornholm, and that by 1755 they had nearly extirpated the Black Rats at Bornholm.

According to R. Brown (*Arctic Manual*, 1875, 21), the species was carried to Greenland by Danish ships as far back as the days of Fabricius, *i.e.*, prior to 1780.

Collett states that the earliest Norwegian record is contained in Ström's MS. diary (1756-1780), now deposited in the University Library of Christiania; Ström says that these rats arrived at Söndmör from one of the neighbouring islands in 1762 and 1763, that they were called "Sö-Rotter" or sea-rats, and in 1776 had become so numerous as to be called the "common kind." According to Svabo,[1] this species was first introduced to the Færöes in 1768 by a ship called *The King of Prussia;* while on a voyage from Norway to Dublin, this vessel was wrecked on the coast of Lewis, and the wreck drifted thence to Suderö. The species spread quickly throughout the islands, and was called by the inhabitants "the great or new rat," in contradistinction from the "common rat" (*rattus*) with which they had long been familiar. Svabo gives much information, with dates, relating to the progress of this species in the Færöes between 1768 and 1781. In Sweden it does not seem to have been known before 1790, and the earliest mention of it appears to have been made by Thunberg in 1798.

In France the species was said by Erxleben to have arrived at Paris in 1750, but it was not known to Buffon prior to 1753. It did not appear in Switzerland before the beginning of the nineteenth century (1809, Schintz, Blasius, and Fatio). In Spain its introduction dates from the end of the eighteenth or the beginning of the nineteenth century (Cabrera); and in Italy perhaps from the middle of the eighteenth century (de Selys; Nickel, *Zool. Garten*, 1874, 155).

A certain wealth of tradition has gathered around the advent of this species in **Britain**. According to one old legend it first came to **England** from Germany in the very ship which brought William of Orange over in 1688 (Charles Waterton's *Essays on Nat. Hist.*, ser. 1, 211); and according to another, positively supported by Waterton's father, it accompanied the House of Hanover on its emigration from Germany in 1714—hence the name "Hanoverian Rat," frequently bestowed upon this species by the British in the eighteenth century. Others, as Smith (*Universal Directory*, etc.), maintained that it came from Norway in timber-laden ships—an impossibility, because the species at that time did not exist in Norway. Pennant put the date of its introduction to England as about 1728 or 1729, and this date has been adopted by Boyd Dawkins, and most other writers. In all probability we received our first stock with cargoes from vessels trading with Russian ports.

Its arrival in **Scotland** dates from the period between 1764 and 1774, according to Walker (*Mammalia Scotica*, 498), and it reached Selkirkshire between 1770 and 1777; its progress from Selkirk to the upper valley of the Tweed, between 1776 and 1792, is narrated in the

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[1] Svabo's unpublished MS. reposes in the library of the University of Copenhagen, and was the chief source of the zoological information given by Landt (*Forsög til en Beskrivelse over Færöerne*, Kjöbenhavn, 1800). We are greatly indebted to Dr Knud Andersen for the loan of his MS. copy of parts of this important work.

New Statistical Account of the Parish of Newlands, Peeblesshire, 1834, 137; the date of its arrival in Morayshire is given as about 1814 by the Rev. G. Gordon.

We have no certain information as to the date of its introduction to **Ireland**, but this probably happened soon after the arrival of the species in England. Rutty (*Nat. Hist. of Dublin*, i., 281) says, however, that it "first began to infest these parts about the year 1722."

The species first arrived in the United States of America, probably from England, about the year 1775; according to Audubon it was still unknown from the Pacific coast in 1851, although its introduction must have occurred there soon afterwards (Lantz, *The Brown Rat in the United States*, 1909, 13).

The success of this animal as a colonist seems largely dependent upon temperature and climate; but the abundance or scarcity of food, the presence or absence of suitable shelter, and the nature of the competition to be faced, are doubtless factors of equal importance in governing the distribution of this, as well as of other species. It has therefore met with varied fortune in the many lands it has invaded. In India, where the *rattus* group is at home, the foothold of *norvegicus* appears insecure; its colonies do not spread far from the landing places, and it seems wholly incapable of displacing the native rats.[1] In warm temperate countries, like Italy and Spain, it has acquired a good footing, but is forced to share the land with the "wild-coloured" sub-species of *rattus*. In temperate Europe its success has been marked; it has spread everywhere and has practically ousted *rattus*. Similarly on its arrival in New Zealand it promptly extirpated "*Mus maorium*," Hutton, *i.e.*, the descendant of the *rattus* stock previously introduced by Europeans. In Switzerland its progress has been slow; it appears to have entered from Germany across the Rhine and Lake Constance, and by 1869 had become common in some of the central Swiss cities, as Berne and Lucerne; but although at that time known from many towns and several cantons, it had nowhere risen to any notable height in the mountains; and Fatio doubted whether it was established then at Geneva, where the *rattus* group still predominated. In Sweden and Norway it has almost completely displaced *rattus*, but its range shows limitations similar to those of its predecessor, and it is scarce in the most northerly districts. In Norway its advance is said, by Collett, to be slow; it seems unable to colonise the upper parts of the main valleys, and is lacking from the floors of all the tributary valleys; it is still scarce or wanting in many of the coastal districts and inhabited islands. In northern Norway it occurs only in buildings or in certain market places, as at Tromsö and Hammerfest, and when introduced in some localities it has quickly disappeared again. At Tromsö, however, it appears to have met with suitable hospitality, for rewards were paid for 4104 killed there between September 1909 and February 1911.

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[1] Bonhote (*Proc. Zool. Soc.*, 1910, 65) says, however, that *norvegicus* is gradually increasing in East India and Egypt at the expense of *rattus* and other rats.

In America it inhabits most of the thickly populated parts; it occurs from Panama northwards to the Yukon Valley and to Greenland, except on the interior table-lands, and perhaps in a few sections of the south (Lantz). It is very common in California, chiefly in the towns; but in the San Joaquin and Sacramento valleys it has invaded marshy tracts, and occurs far from human habitations (Grinnell, *Proc. Cal. Ac. Sc.*, 1913, 322). It is found also in many parts of South America, where it is often the dominant species; but in the warmer parts of America it is frequently unable to supplant the previously introduced *rattus* group.

It was found on the ship *Advance* of Dr Kane's second Grinnell Land expedition during two icebound winters in 78° 37′ N. latitude; and it also adapts itself to the continuous low temperatures of cold-storage stations (Lantz). Brown says that when carried to Greenland in the time of Fabricius these rats "seemed likely to prove dangerous in houses; but they gradually and periodically died out, as they could not stand the cold of winter. Some years ago they were again introduced, and still occasionally one is seen in the summer months in some of the warehouses from Upernavik to near Cape Farewell." It is therefore unlikely that this species could survive for many generations under very severe climatic conditions; and possibly its present discontinuous distribution in Asia, noticed above, is to be explained as a result of the great changes of climate which apparently ensued in the northern and central parts of that continent towards the close of the Pleistocene.

The species is now widely distributed throughout **Great Britain** and **Ireland**, and it has reached the majority of the islands around the coast, being found on Jersey, Guernsey, Wight, Scilly, Lundy (Coward), Anglesey (Coward, *in lit.*), Man, Skye, the Hebrides, Ailsa Craig; on smaller Scotch islands, as Sanda, Sheep, Glenimore near Kintore, Sgat Mhor in Loch Fyne, and Inch Moan (Boyd Watt); on Orkney (Barry, *op. cit.*, and Wolley, *Zoologist*, 1849, 2344), Shetland, the Saltee Islands (Barrett-Hamilton, *Zoologist*, 1891, 6), Clare Island, and Inishmore. Drane did not find it on Skomer, and it is not known to occur on St Kilda.

Distribution in time, and origin:—Nothing is definitely known of the geological history of *E. norvegicus*. As shown above, its place of origin is apparently temperate Asia, where it probably dates from the Pleistocene.

Status:—The present species appears to be rather more specialised than is *E. rattus*, and in a somewhat different direction. While *rattus* is essentially fitted for a free, semi-arboreal life, *norvegicus* has pursued a more earth-bound course. It has acquired accordingly a stouter and heavier body, a shorter tail, and its structure, in many points, has suffered modifications adapting it for burrowing, swimming, and the other activities incidental to its peculiar mode of living.

Description:—Though generally resembling *E. rattus* in form, the Common Rat is characterised by its relatively large size, great weight, robust form, short, thick ears, and by its shorter tail, which is never as long as the head and body.

The snout is relatively blunt. The eyes are small, though somewhat larger than in *rattus*. The **ears** are short, about one-third as long as the head and scarcely reaching the eyes when laid forward; their substance is thick and opaque, and they are clothed with fine short hairs; in young animals they are relatively large and thin. The **hands** and **feet** are much like those of *rattus*, although more robust; the fingers and toes have similar proportions, and the number and positions of the palmar and plantar pads are essentially the same in both species. The pads, especially those of the sole, are, however, relatively small in *norvegicus;* in the hand and foot there is sometimes a small free pad external to that at the base of digit 5; and in the foot another is occasionally present, to the inner side of that at the base of digit 1. The **tail** differs from that of *rattus* in being shorter and stouter, while the annulations are masked to some extent by the greater distinctness of their component scales; it has about one hundred and eighty rings in all, and a few small hairs rise from beneath each scale. The female has twelve mammæ, arranged as two pectoral, one abdominal, and three inguinal pairs.

Pelage:—The underfur is thick. The grooved bristles are much finer and present in much fewer number than in *rattus*, the long black dorsal hairs are shorter; in consequence of these differences the fur as a whole is rather softer and less harsh in quality than that of *rattus*, but the greater length of the underfur imparts a rougher and shaggier appearance, particularly noticeable on the belly, than that of *E. rattus rattus*.

The whiskers are relatively short, not extending beyond the ear when pressed backward; the lower ones are whitish, the remainder black in colour.

In the typical form the **colour** is darker on the back, where the tips of a greater or less number of the hairs are black, and lightens towards the sides, where dirty yellowish or whitish hair tips predominate. The general tone of the upper parts is a very variable greyish-brown, lined with black, and with an occasional reddish tinge over the rump and loins. The underside is variably lighter, the colour of the belly varying from silver to a light yellowish-brown. Except under the chin, where the hairs are white throughout, all the hairs have slaty or dusky bases. The ears are of a dull hair-brown. The hands and feet are greyish flesh-coloured (not pink as in *rattus*). The tail is inconspicuously bicoloured, being a dull dark brown above and yellowish-white below; the fine hairs, which clothe it but do not conceal the skin, are blackish above, whitish below.

Barrett-Hamilton observed the **moult** in a specimen of "*hibernicus*" taken at Kilmanock on 3rd August 1912. There is probably also a spring moult; O. Jones (*A Gamekeeper's Notebook*, 26) says the coat is rusty red then, especially if the rats are living in burrows in soil, and if short of food or living on carrion, which delays the moult. It is probable that all murines have distinct summer and winter coats.

The pelage of the **young** (soon after they have left their dam) does not differ conspicuously from that of the adults: it is rather softer, fuller, and duller in colour. The young are slenderly built; their ears relatively thin and, together with the tail and feet, relatively longer than in the adults. On cursory examination they may easily be confused with *rattus*, but all may be correctly determined by comparing their proportions with those of *rattus* of similar age, apart from the quality of the fur and the characters of the skull.

Local variation:—William Thompson's (*Proc. Zool. Soc.*, 1837, 52) description of the **Irish Rat**, *Mus hibernicus*, has given rise to a bulky literature. It was supposed to be characterised by the possession of white fore-limbs and of a white breast spot, but these have since proved to be very variable characters, more frequently absent than present, the chest spot when present being of various and often asymmetrical shapes. Apart from these features, *hibernicus* differs from ordinary brown specimens in the uniform dusky hue of the complete pelage and the absence of a white underside; and it is, in this respect, parallel to melanisms of the rabbit. The skin also is dusky, and a peculiarity is the frequent presence of numerous grey hairs on the flanks, which give a very blue appearance.

No doubt owing to its black colour, it was compared by Thompson with *E. rattus*, and in Bell's 2nd edition it is mentioned by Tomes in the article on that species. Others (as Southwell, *Zoologist*, 1889, 321, and *Trans. Norf. and Norw. N. H. Soc.*, ii., 419) have thought it a hybrid. While fully cognisant of these errors, Eagle Clarke (in Harvie-Brown and Buckley's *Vert. Fauna of the Outer Hebrides*, 1888, 36*a*) was at first led to regard it as a distinct species, but later (*Zoologist*, 1891, 1) he joined Barrett-Hamilton in describing it as an interesting melanism of *E. norvegicus*, an opinion already expressed by Blasius in 1857, and by de l'Isle in 1865 (*op. cit.*, 189). The latter used *hibernicus*, together with the melanistic races of House Mice, in support of his argument, reviewed above, as to the origin of the black pelage in *E. r. rattus.*

This melanism was at first supposed to be confined to Ireland; Barrett-Hamilton received reports of it from at least seventeen Irish counties, and there can be little doubt that it occurs in all the remainder. He notes that "its appearance is sporadic and irregular; in some years it is absent, in others abundant, in the same locality. The young exhibit the melanism from the beginning, and litters may consist solely of black individuals or of some of each colour; thus Pack Beresford sent me a brown female, whose family consisted of eight brown and two black young. Specimens exhibiting intermediate coloration are rare; I have examined a parti-coloured black and brown one (*Zoologist*, 1888, 142)."

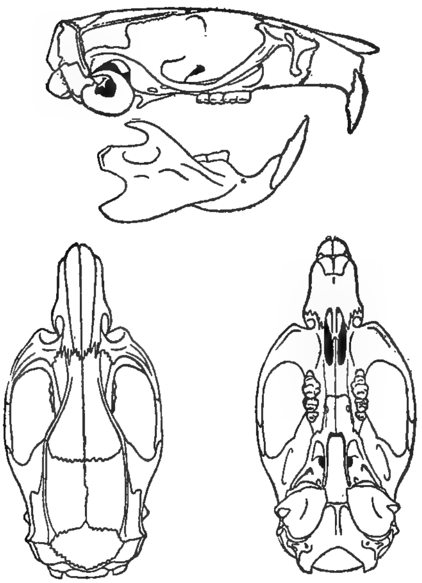

FIG. 91.—SKULL AND MANDIBLE OF *Epimys norvegicus* (life size). Reproduced from Miller's *Catalogue of Mammals of Western Europe*, by the kind permission of the Trustees of the British Museum.

This variation has now, however, been recorded from the Outer Hebrides; from many English counties; from Paris (Milne-Edwardes, *Ann. Soc. Nat.*, 1871, xv., art. 7); and Biarritz (a specimen from this last place seen by Barrett-Hamilton).

There can be little doubt that it is of frequent occurrence, but is confused with *E. rattus* or *Arvicola amphibius;* for instance, when observed in the Zoological Gardens of London it has done duty for *E. rattus* (see Millais, ii., 211; Pocock, *in lit.*, to Barrett-Hamilton). It seems to be a western development of the species, and to afford a close parallel, assuming de l'Isle's view to be correct, to the relations subsisting between *E. r. rattus* and the wild-coloured forms of that species.

The **skull** (Fig. 91) is strongly built and of relatively large size (the condylo-basal length usually more than 45 mm.). Compared with *E. rattus*, the brain-case is relatively narrower; the parietal region is much less conspicuously vaulted, and the rostrum is larger, especially deeper and broader. The dorsal profile is flatter and more nearly horizontal throughout. The masseter and temporal muscles are relatively larger and more powerful than in *rattus*. The zygomatic arches are therefore heavier, and the masseteric plate is wider in proportion to its height. The temporal fossæ are more extensive, the parietal crests, which continue the supra-orbital ridges backwards to the hinder edges of the squamosals, running at a higher level (in an old skull of *E. r. rattus* the greatest distance between these crests equals 88 per cent. of the cranial width, but in a similar skull of *norvegicus* it equals 73 per cent. only); the greatest distance between these crests is about equal to the length of a parietal measured along a crest. The posterior border of the interparietal is nearly straight instead of boldly convex, and the backward deflection of the central part of the lambdoidal crest is correspondingly slight.[1] The auditory bullæ are rather smaller, and the anterior part of the basi-occipital is relatively a little wider. The processes of the premaxillæ supporting the nasals in front are relatively small.

The **mandible** is of normal murine form, with large angular and coronoid processes; the incisor roots produce well-marked though small humps on the outer sides, below the coronoid processes; the latter rise considerably above the condyles.

The **cheek-teeth** (Plate XXVIII., Fig. 9) are slightly more specialised than those of *E. rattus*. In the upper molars the median tubercles are somewhat increased in size, while the outer row is more reduced and the tendency towards lophodonty is more marked. In m^1 there is usually an anterior basal cingulum; cusp 1 is much smaller than x, and is fused with the latter from a relatively early stage of wear; cusps 4 and 5 are also smaller than in *rattus*, and more intimately connected with y and z respectively. Cusps 1, 4, and 5 can all be distinguished in m^2 and m^3 when slightly worn, and 4 is rather well developed, though smaller than in *rattus*, in m^2. In the lower teeth also the outer row is more reduced than in *rattus*; in m_1 it is represented by a minute cusp 6; in m_2 and m_3 cusp n is present though small, and in slightly worn examples of the m_3 the posterior lobe is seen to consist of two intimately connected tubercles—y and 4.

Some details of the **osteological** differences between *norvegicus* and *rattus* are given by de l'Isle (*op. cit.*, 219); most of the bones of the former differ from those of the latter species in showing larger surfaces for muscular attachment.

Exceptional variation:—The mammæ, as is well known, are rather variable in number in *norvegicus*, and also in *rattus*. Hossack found the typical $\frac{3-3}{3-3}$ formula in eleven out of nineteen specimens of *norvegicus* examined; the formulæ found in the remainder were: in four, $\frac{2-2}{3-3}$; in one each, $\frac{1-1}{3-3}$, $\frac{4-4}{3-3}$, $\frac{3-3}{2-3}$, and $\frac{3-3}{4-3}$. Elmhirst (*in lit.*) notes one from Great Cumbrae with the formula $\frac{4-3}{3-3}$.

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[1] Fig. 91 though giving a good general idea of the skull, does not portray the normal appearance of the occipital region in this species.

Hairless rats have been recorded by Bree (*Field*, 5th Oct. 1872, 328), who sent two to the Royal College of Surgeons; one, almost hairless, with transparent yellow skin, is mentioned by Millais (ii., 232); one from Leyton, Essex, is recorded by Beddard (*P. Z. S.*, 1903, ii., 336); and another from Devonport by Belcher (*Zoologist*, 1904, 72).

A very large number of colour variations have been recorded for this species, a circumstance due to the density of the rat population and the enormous numbers which come under observation rather than to any greater instability of coloration than in allied species. Space will not permit of a complete list of the variations which have been observed among wild rats, but they may perhaps be classified as follows[1]:—

1. Pure albinos; white with pink eyes.
2. Partial albinos; including silvery grey, fawn, and sandy animals, with or without pink eyes.
3. Partially or completely melanic individuals.

In some cases the variation affects the whole coat; in others it is only seen in portions of the coat, so that spotted, pied, or particoloured rats are the result.

Such variations are frequently transmitted by heredity, and may become characteristic of local races. The most striking instance of this sort is, of course, that afforded by *hibernicus* discussed above. Lord Headley discovered a peculiar race on an island in Lough Corrib, Co. Galway; eleven caught there were buff or fawn, "desert" coloured rats, with ruby eyes. Millais mentions sandy coloured rats found on the seashore of Tiree, and he compares them with the peculiar House Mice of North Bull, Dublin.

E. norvegicus is frequently bred in captivity, and many variations of colour and pattern have shown themselves in the course of domestication; these variations have been studied by Crampe, Doncaster, Mudge,[2] and others, from a Mendelian standpoint. Pocock[1] states that all the fancy rats kept or seen by him were unmistakably specimens of *norvegicus;* and Lantz[2] says that the only albino rats in the collections of the United States National Museum and Biological Survey are of this species. It is therefore very doubtful, despite statements to the contrary,[3] whether any of the tame rats of commerce are other than *E. norvegicus.* Lataste (314) thinks that the white variety is the commonest and most ancient of these tame races—it being known to his friends from at least about 1857—and that the other varieties are rarer and more recent productions. Millais (ii., 218) says that although there was a National Mouse Club in the nineteenth century, it was not until the twentieth century that classes for fancy rats came into notice at the shows.

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[1] Reference may be made to the following, though quite incomplete, list of the literature for details of representative cases:—G. B. Corbin, *Zoologist*, 1873, 3525; J. Gatcombe, *ibid.*, 1874, 3996; J. Sclater, *ibid.*, 1876, 5039; B. H. (Llandudno), *Field*, 1st August 1885, 192; E. W. Gunn, *Zoologist*, 1889, 144; G. T. Rope, *ibid.*, 1890, 97; R. I. Pocock, *Field*, 22nd June 1907, 1063, and 18th May 1912, 997; and A. J. Bengough, *ibid.*, 2nd December 1911, 1234. Other cases are noted by Millais (ii., 221). Cocks has seen an immature albino male in Bucks, and Service informed us of a light grey or grizzled white rat taken in July 1903.

[2] Crampe, *Landwirth. Jahrb.*, 1885, 539; L. Doncaster, *Proc. Camb. Phil. Soc.*, xiii., 1905, 215; G. Mudge, *Proc. Roy. Soc.*, 80, 97, 1908.

Brehm (*Thierleben*, ii., 125) mentions artificial "King Rats" (see p. 592) as known in 1774 and 1822, and Lataste (352) thinks they must have been tame *norvegicus.* Blind rats (four out of a litter of five) have been recorded by Cocks (*Zoologist*, 1903, 430), who informs us (*in lit.*) of two other cases from Poynetts, near Henley, viz., three out of five young rats (head and body, 100 to 110 mm.) on 8th January 1904, and another about two-thirds grown on 16th July 1914. The cause of the blindness appears to be obscure though post-natal (see below, p. 641).

Geographical variation:—The only race at present recognised as a distinct sub-species from the typical European Brown Rat is *E. n. primarius*, Kastchenko, described from the Trans-Baikal region. This form is represented in the British Museum collection by a series collected in July 1914 by Mr G. A. Burney at Musavaia, Trans-Baikal, and Leestvineechnova, Irkutsk. It is characterised by its somewhat shorter tail (averaging about 76 per cent. instead of about 82 per cent. of the length of the head and body); smaller hind feet (31 to 37·5 mm.); longer and softer fur, and darker dorsal coloration. The tail is rather densely clothed with very fine silvery hairs; its skin is distinctly bicoloured in younger specimens, but apparently has a tendency to become paler above with advancing age. The feet are silvery white. The young have a very soft and full coat, dusky above, leaden below; a few of the hairs on the head and shoulders have yellowish-brown tips, while those of the under parts are silver-tipped.

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[1] R. I. Pocock, *Field*, 15th June 1907, 1015; and *ibid.*, 18th May 1912, 997. Capt. S. Flower mentions, in the *Report of the Giza Zoological Gardens*, the births of many white rats of this species in 1907 (see also *Field*, 27th June 1908, 1117).

[2] D. E. Lantz, *The Brown Rat in the United States*, 1908, 14.

[3] *Cf.* Millais (ii., 217): "It is scarcely necessary to say that all the rats sold in the fanciers' shops are domesticated varieties of *Mus rattus.*"

DIMENSIONS IN MILLIMETRES:—

EPIMYS NORVEGICUS.

SEXUALLY MATURE SPECIMENS FROM KILMANOCK, WATERFORD, IRELAND, CAUGHT AND MEASURED BY G. E. H. BARRETT-HAMILTON.

Males.	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.	Females.	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
1. Undated . .	216	178	36	20	..	1. Undated . .	229	178	40	21	..
2. ,, .	216	191	38	18	..	2. 13th Mar. 1908	267	184	40	20	453
3. ,, . .	222	..	40	20	..	3. 10th Aug. 1909	216	178	38	21	..
4. ,, .	222	165	..	20	..	4. 13th Oct. 1910	267	203	40	20	..
5. ,, .	241	203	42	23	..	5. ,, ,, ,,	222	178	38	19	..
6. ,, . .	229	178	41	21	..	6. ,, ,, ,,	235	178	35	20	..
7. 13th Mar. 1908[1]	254	222	43	20	453	7. ,, ,, ,,	241	203	39	19	..
8. 10th Aug. 1909	229	197	40	21	..						
9. ,, ,, ,,	229	..	40	21	..						
10. ,, ,, ,,	203	178	40	21	..						
11. 13th Oct. 1910	273	..	41	20	..						
12. ,, ,, ,,	254	178	40	20	..						
13. ,, ,, ,,	229	203	38	21	..						
14. ,, ,, ,,	229	216	40	20	..						
15. ,, ,, ,,	235	..	40	20	..						
16. ,, ,, ,,	235	203	41	20	..						
17. ,, ,, ,,	210	203	41	20	..						
18. 8th Mar. 1911 .	267	229	45	20	502						
19. 20th Sept. ,,	241	..	41	19	516						

[1] Males Nos. 7 and 19 were black specimens ("*hibernicus*").

Weight:—Of twenty "ordinary" and apparently adult rats weighed at Kilmanock on 13th October 1910, fifteen males averaged 13·6 ounces, or 385 grammes, and five females averaged 14·5 ounces, or 411 grammes. Higher weights are given in the table above, but specimens weighing more than 17 ounces, or 481 grammes, are exceptional. Two examined by the editor of the *Field* reached 20·5 ounces, or 581 grammes (a male), and 23 ounces, or 651 grammes, respectively (*Field*, 30th July 1887, 199, and 5th January 1889, 27). Neglecting anonymous records, there are at least six other records in the *Field* of weights of over 20 ounces; of these the two heaviest are here given for what they are worth:—A male, 29 ounces, or 821 grammes, killed 1st January 1900 (R. B. Whitford, *Field*, 20th January 1900, 95); one, 31·5 ounces, or 892 grammes, killed in 1883 (F. W. Cock, *Field*, 21st January 1888, 91); but it would be safer to take the 23-ounce specimen examined by the editor as holding the record.[1]

Skull:—Condylo-basal length, 43·4 to 54·2; zygomatic breadth, 20·2 to 28·6; interorbital constriction, 6·2 to 7·6; occipital breadth, 16·2 to 21·2; median occipital depth, 10·4 to 13·4; length of a nasal,

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[1] It is worthy of note that this specimen was sent in as weighing 28 ounces; it must be remembered, however, as Mr Cocks points out, that animals when dead very soon begin to lose weight.

16·4 to 22; diastema, 12 to 15·6; maxillary tooth-row, 6·8 to 8·8; mandible, 26 to 33; mandibular tooth-row, 6·8 to 8·4.

Distinguishing characters:—The Common Rat in all colour phases is readily distinguishable from any sub-species of *E. rattus* by its stouter build, greater weight (in relation to length of head and body), shorter tail, shorter and thicker ears, and its larger hind feet. The skull is characterised by its greater size and the peculiarities of form in the parietal and interparietal regions described above.

The Common or Brown Rat is probably the most injurious and universal mammalian pest of the human race, and its habits are so well known as not to require description; or, rather, they are so wide as to be comparable with those of man himself, and would therefore require a volume for exhaustive treatment. It does not appear to have a single redeeming feature, its value as a scavenger being now negligible.

Disregarding exceptional conditions, rats are wide-foraging animals, dwelling in secure burrows,[1] where they lie up in a warm nest of grass or other materials, and to which they carry their food, at least when abroad by daylight; but probably from reasons of prudence their forays take place chiefly at night. Being powerful diggers, they are quick to construct new burrows in the neighbourhood of food, and sometimes these are merely temporary shelters, not occupied for purposes of sleeping. The proximity of the food supply usually governs the situation of the burrow, but there is no rule for its extent or situation; it generally consists of several winding galleries, and possesses more than one entrance. The animals are apparently loth to make unnecessary excavations, and they are quick to burrow in heaps of soft material, such as manure (which is also warm). For the same reason, perhaps, they are great frequenters of ricks,[2] which also supply them with food; of the burrows of rabbits, where they devour the young; and above all of dwellings and outhouses, where they lie up in the floors, walls, or more rarely, in the roofs (though common in thatch). Their teeth are so powerful that they rapidly gnaw a way through wooden partitions; they have been known to damage lead pipes,[1] and will even break through cement if they can attack it before it has hardened. Sometimes they construct clumsy nests, like those of the House Sparrow,[2] in thick bushes or hedges.

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[1] Sometimes at a distance from their food—see *Field*, 17th July 1886.

[2] Owen Jones records the capture of 600 rats from one rick, 1000 from two, and 1300 from three other ricks.

They have a special propensity for exploring underground passages, such as sewers or drains, where no doubt they pick up much food; and, as they swim and dive with almost as much facility as purely aquatic mammals, they thus tend to be found in exceptional numbers by streams or rivers, with consequent damage to embankments and reservoirs.

Where they are abundant they make beaten paths or "runs," distinguishable from those of rabbits by the continuously smoothened surface, since the stride is much shorter than that of rabbits, and by the spindle-shaped droppings.

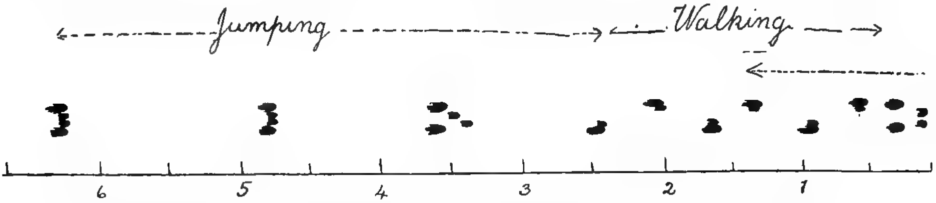

FIG. 92.—SPOOR OF RAT (Diagram from sketch and measurements made by Barrett-Hamilton at Kilmanock.)

One such pathway leading from burrows to a feeding place is said to have measured 500 paces in length.[3]

The tracks of rats (Fig. 92) show that when walking the hind feet tread partly upon and partly to the outer sides of the prints left by the corresponding fore feet, the length of the stride being between 8 and 10 in. As the pace increases the animal breaks into a series of leaps and covers a distance of from 13 to 18 in. at each bound. In these leaps the hind feet strike the ground together a little in advance, and to the outer side, of the prints left by the fore feet; the latter prints lie side by side close to the centre of the track. The extreme width of the track is about 3 in.

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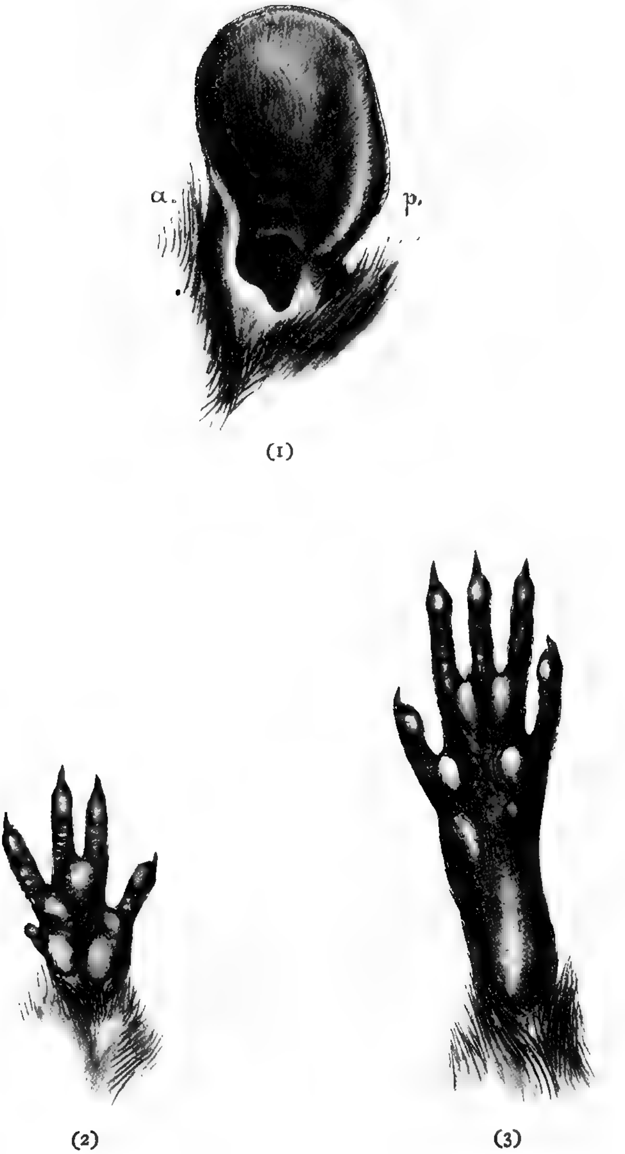
[1] Gnawing of lead from a sash-weight—H. Burroughes, *Zoologist*, 1852, 3473; leaden pipes (*Field*, 17th Feb. 1894, 230; *ibid.*, 10th March, 353 (illustrated), 24th April, 474. Specimens of gnawed pipes are in British Museum (N.H.).

[2] *Passer domesticus.* Whole "ratteries" were reported as existing in hedges in New Zealand—see *Proc. N.Z. Institute*, 1870, 47; and *Zoologist*, 1887, 189.

[3] Jesse, *op. cit.*, 231.

PLATE XXXIII.



THE COMMON RAT—*Epimys norvegicus.*

(1) LEFT EAR (twice life size); (2) LEFT HAND AND (3) LEFT FOOT (one and a half times life size).

Without being specialists, they are excellent climbers, so that it is difficult to imagine a situation to which they could not penetrate. Barrett-Hamilton (MS.) says, "My own home is rat-proof as regards the basement, but a constant watch and ward is still necessary to keep rats from entering by open doors and windows, and they have several times, by climbing up the walls, found their way to the roof. In climbing, the tail is used as a balancing organ, and to a very small extent tends to be prehensile, especially when the animal is descending, opportunity being taken to twine it round any available object."[1]

One of the chief factors leading to the success of rats is their excellent social system. Although the old males seem to live apart[2] in special burrows of somewhat simple construction, the bulk of the species are eminently sociable animals, not separated off in mutually exclusive clans like Water Rats. This is shown when one is introduced into a receptacle containing other rats. Unless one be wounded no objection is raised to the arrival of the new-comer, who, although a stranger, is invariably received as a comrade. Perhaps for this reason a man can insert his hand amongst a lot of caged rats and handle them without fear of being bitten;[3] and where a rat is killed its place is rapidly occupied by another so long as any trace of the original one remains, either by way of smell or otherwise. Similarly in a garden one may grow tulips for years without their being discovered by rats. Should, however, one rat discover and dig for the bulbs, it is little use trapping him, for every rat that passes will be attracted by the "signs" of its predecessor. They are diabolically intelligent animals, and where a bed in a garden has been recently dug over, will excavate anything planted in it, apparently for the sake of curiosity.

So intelligent are these animals, that they are believed to resort to combination for the attainment of a desirable object, as when two assisted each other to push a dog-biscuit through the bars of a cage.[1] This is a point, however, at which narratives tend to verge on the poetical.

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[1] *Cf.* Millais (ii., 181), who points out that in the Dormouse the tail is only a balancer; in rats and mice it is almost prehensile; while in the Harvest Mouse it is specialised for prehension.

[2] A. H. Cocks, *Bucks.*

[3] Cocks says this is so if there are not fewer than three rats present.

Unlike the various wild mice, rats are very suspicious of traps, but often succumb to their propensity for running through holes or apertures; for instance, if two boards be placed on their sides so that the "run" passes through a narrow aperture left between the boards, the rats will use the fenced part of their pathway rather than climb over one of the boards, and may thus be trapped.[2]

Although Common Rats frequent houses and ships, they do not succeed so well in these situations as the Black Rat, which is a far superior climber.

The dietary of the Common Rat is very wide, almost as wide probably as that of the domestic pig. The food of any particular rat varies with its situation. In Ireland they are so abundant that practically every part of the country, except the bare hillsides and possibly the forests, is overrun with them, and consequently the food available for any particular individual is peculiar to its habitat. But should one food fail, the animal is always ready to take to another, thus rendering starvation a remote possibility. On the seashore the food is what is cast up by the sea, together with prawns, shrimps, shell-fish, fish, eggs and young of sea birds,[3] and vegetable matter; in marshes or pastures, mushrooms, frogs and their spawn, toads, mollusca,[4] insects,[5] fish, and small eels;[1] in cultivated lands, all sorts of leaves, stems, flowers, roots,[2] or grain; in towns and houses, milk, butter, cheese, bread, flour, jam, and refuse of all sorts; on roads, the undigested portions in the droppings of animals; in game preserves, dovecots, or farmyards, young pheasants, pigeons, ducks, or poultry; in old walls, snails, rejecting the shells;[3] in meadows, grass-seed;[4] in orchards, fruit;[5] in warrens, young rabbits.[6] Everywhere and at all times young, small, or weakly vertebrates[7] are hunted with a ferocity suggestive of a lust for killing, since the victims are often left uneaten. Wherever domestic animals feed or are fed, a host of these marauders attends to assist in the meal or clear away the leavings. One result of this ubiquity is that it is of very little use for one person to trap and destroy them. Those killed amid the flesh-pots of a farmyard simply leave vacancies for their ravenous brethren of the barer fields.

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[1] T. W. Kirk, *Nature*, 10th September 1884.

[2] Owen Jones recommends setting the trap on the worn spot where a rat jumps down.

[3] These (or young chicks) are often removed from under the sitting bird without disturbing her. Much ingenuity is often displayed in removing them intact to the burrow; the methods used are mentioned on p. 415, article Bank Mouse. For sucking blackbirds' and robins' eggs, see R. Wayne, *Zoologist*, 1849, 2495; and for a case where an egg was removed by one rat embracing it, the other pulling it by the tail!—H. Moses, *Zoologist*, 1865, 9431 (seen by a clergyman).

[4] Including mussels—fresh-water or marine. Cocks tells us that, on the Thames, the Brown Rats bring ashore and eat large numbers of mussels. For the corresponding habit of the Water Rat, see p. 494. In some parts of New Zealand they are stated to have almost extirpated a native species of crayfish and to dive for mussels (*Unio*); these latter they open on the bank (*Zoologist*, 1887, 189).

[5] Whence they receive the same tapeworms and other parasites as hedgehogs and small carnivora (Shipley, 65). Cocks has known rats to feed on the intestines of living ducklings.

It is quite marvellous how they discover where animals are fed. They even find their way into mines.[8] Barrett-Hamilton saw them chasing birds coming to feed on crumbs in times of snow, and they will take the water to quarrel with water-fowl at feeding time.

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[1] Lamperns—E. Brown, *Zoologist*, 1843, 212. Eels—J. Hardy, *Zoologist*, 1846, 1364; R. Lydekker, *Royal Natural History;* Shipley, *op. cit.*, 65.

[2] Swedes—R. M. Barrington (*Zoologist*, 1878, 178) and many others have pointed out that in eating a swede, which they prefer to a turnip, rats gnaw right round the root, ending (if they do not pass on to another one) in the centre; they also bite off and reject bits of the rind, which lie conspicuously on the ground. Hares are also said to reject the rind (H. Miller, *Zoologist*, 1878, 100), but they and rabbits differ from rats in gnawing right through the root from one side to the other. Another and safer method of distinction would be afforded by the size of the marks made by the incisors of the three rodents.

[3] Snails—Merrifield, *Sketch of the Natural History of Brighton*, 157; Harting, *Zoologist*, 1887, 190, *Rambles in Search of Shells*, 73, and *Vermin of the Farm*, 4.

[4] Hence a handful of "hay-seed" is a very useful thing for sprinkling over rat-traps.

[5] Climbing the trees for apples and cherries (*Field*, vol. 78, 660); morella cherries, J. B. Ellman, *Zoologist*, 1848, 2223.

[6] Hence rabbit-trappers have frequently to kill off the rats in rabbit burrows before they can secure the conies. Puffin Island, off Anglesey (Robert Stephenson), and the Skerries, near Holyhead, are said to have had their stocks of rabbits destroyed by rats which escaped from shipwrecks (Pattisson in Bell, ed. 2, 313).

[7] Smaller rats—R. M. Barrington, *Field*, 1875, 4662. For conflicts between rats and hedgehogs—the former not always being the aggressors, see p. 62 above.

[8] "Coal-mines"—G. Roberts, Wakefield, *Zoologist*, 1867, 553.

Occasionally, as reported in the daily press for Midlothian and Lincolnshire in 1889, rats become so numerous as to constitute a recognised "plague." These increases are parallel to those occurring in other rodents, and may have been more frequent in former times when the Black Rat held undisputed sway in this country.

Food and other articles are always carried away, if possible, to the burrow. A single nest was found to contain three towels, two serviettes, five dust cloths, two pairs of linen knickerbockers, six linen handkerchiefs, and one silk handkerchief; near this nest were 1½ lbs. of sugar, a pudding, a stalk of celery, a beet, carrots, turnips, and potatoes.[1] Millais states (ii. 224) that 1728 gnawed serviettes were found behind the wainscot of a London restaurant.

A partial migration is performed according to season from the open country in summer to the shelter of farms and houses in winter; and similar movements take place where food varies with the season. For instance, herring fisheries are said[2] to attract large numbers to the coast every year, the rats returning inland on the cessation of the fishery in October. In foreign countries very much larger and more irregular movements have been noticed.[3]

Mr Cocks (*in lit.*) relates a remarkable experience in Heligoland many years ago. While walking along the cliffs he shot a Peregrine Falcon, which fell on the rocks below. As soon as the tide permitted he set off, along the shore, to retrieve his prize. It was an autumn evening, and "presently, in the complete solitude and silence, I was very much startled by a sort of rushing sound, as of countless feet. The next moment I began to be passed from behind by a legion of rats, numbering at least little short of, and quite likely considerably over a thousand, who made their habitat at the base of the cliff, and came out when the tide fell, looking for food. I never saw anything like it before or since. We did not interfere with each other, though they perforce had to pass me quite close."

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[1] *Field*, 10th Jan. 1891, 46; Lantz, *op. cit.*, 29.

[2] Lantz, *op. cit.*, 17.

[3] Lantz, *loc. cit.*

The rat flourishes on a shore diet. It thus manages to subsist on many of the smaller islands, as on Ailsa Craig, where it arrived in 1889, and eats the innumerable dead bodies of sea-birds falling to the bases of the cliffs.[1]

As a rule rats do not directly molest large animals, but they have been occasionally known to attack or kill men[2] or children,[3] and to gnaw the feet of elephants in the Zoological Gardens.[4] Their tendency to cannibalism is interesting in view of the fact that, as described above, they are at ordinary times friendly to all members of their species. Either they run amuck sometimes, or else they attack each other through some mistaken sense of injury.[5] Stories of rats eating each other when left over night in cages cannot be regarded as instances of their normal habits, since their sufferings from thirst and hunger probably madden them, and may lead them to connect their troubles with their comrades, as many "game" animals do when wounded by a shot from an unseen hunter.

Extraordinary calculations have been made as to the damage done by rats and the rate of their increase. F. von Fischer[6] calculated that a single pair might leave, after ten years, a progeny of 48,319,698,843,030,344,720 rats.

Mr Lantz[7] calculates that in nine generations a single pair of rats would, if breeding uninterruptedly, produce more than twenty million individuals, but such a calculation is entirely theoretical. However, as he states that the average quantity of grain consumed by an adult or half-grown rat is fully 2 ounces daily, or 45 to 50 lbs. a year, the average cost for feeding one rat for a year becomes about seven shillings and sixpence. If fed on meat, the cost would be higher, but the calculation is complicated by the fact that rats eat much waste products and, on the other hand, damage more than they eat. Many rats must each destroy fully five shillings' worth of property annually. The real numbers of rats are probably not realised by ordinary people. In 1901, about 37,000 were killed on a farm of 2000 acres near Chichester,[1] and over 12,000,000, mostly of the *E. rattus* group, were killed in certain parts of India[2] in the years 1878-79. Dr A. E. Shipley,[3] assuming the rat population of Great Britain and Ireland to be about 40,000,000, or one for every human being and slightly less than one per acre, estimated the total annual loss occasioned to us by rats at the huge sum of £10,000,000, while Sir James Crichton-Browne[4] has even placed the damage at £15,000,000 per annum.

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[1] Boyd Watt, *Ann. Scott. N.H.*, 1892, 132.

[2] In Walker Colliery, Killingworth, *fide* Robert Stephenson, M.P. (the distinguished engineer), quoted by Tomes in Bell, ed. 2, 311 ; see also Millais, ii., 229.

[3] Shipley, *Journ. Econ. Biol.*, iii., 1908, 65.

[4] Frank Buckland, *Curiosities Nat. Hist.*, i., 76 ; and Millais, ii., 229.

[5] Such highly "civilised" animals as dogs occasionally murder each other when confined together in numbers.

[6] *Zool. Garten*, 1872, 125.

[7] Lantz, *op. cit.*, 16.

Sometimes rats cause destructive fires by stealing and accidentally igniting lucifer matches,[5] or by gnawing through gas pipes they give rise to inflammable leaks[6] or asphyxia of the human inhabitants.[7] Sometimes they destroy the insulating covering of wires used for electric lighting,[8] which may again result in conflagrations.

Inasmuch as rats are quite palatable animals,[9] it might be thought that all flesh feeders[10] could live upon them; but their ferocity and vigour in defence is so great that most carnivorous creatures, though glad to catch the young, pause to reckon the consequences before attacking a full grown rat—if she be a doe with young her prowess is increased tenfold.[11] Only strong dogs, ferrets, or cats, will face rats, but still, combined with trappers, professional or desultory, foxes, owls, and other creatures, together with the plan of bacillus infection, which appears to have met with some success recently, a large toll is annually taken, but seems to have no effect on their numbers. Sooner or later civilised man will have to face the problem of totally destroying these pests, but hitherto his efforts have met with practically no success. In Japan alone several hundred thousand to a million rats are said to be killed annually, but without producing any sensible diminution of the numbers present.[1] The cutting-off of the chief sources of food-supply, thus reducing the number of young, and the universal erection of rat-proof dwellings, as recommended by Mr Lantz,[2] if combined in a systematic manner with trapping, may prove more effective in the long run than the present desultory campaign.

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[1] *Field*, 27th Sept. 1902, 545.

[2] *Brit. Med. Journ.*, 16th September 1905, 623.

[3] Shipley, *op. cit.*, 66.

[4] *Journ. Incorp. Soc. for the Destruct. of Vermin*, i., 74, October 1908; for other countries, see Lantz, *op. cit.*, who calculates the annual loss to the citizens of the United States of America as $20,000,000 = £4,000,000.

[5] As on H.M.S. *Revenge;* see Hardwicke's *Science Gossip*, v., 142, 1869.

[6] As in Phillip's warehouse, Church Street, London; see *Journal cit.*, x., 73, 1874.

[7] E. Newman, *Zoologist*, 1875, 4378.

[8] Lantz., *op. cit.*

[9] Owen Jones states that rat-pie tastes like rabbit if made from well-fed animals.

[10] For a horse killing a rat, see S. B. Wells, *Field*, 1st June 1912, 1110.

[11] Cocks (*in lit.*) says:—"While young rats are useful food for nearly any carnivorous mammal or bird, tough old ones are unwholesome for more delicate feeders, such as Wild Cats or many birds of prey. On one occasion more than twenty years ago, I put a fine old rat alive in, for the supper of a correspondingly fine male Wild Cat. Within a very few minutes the rat disappeared. On the sixth day afterwards, my man opened the door of the cat's 'bed-sitting room,' and found the rat there perfectly well. For five nights the cat and rat had slept side by side, and the rat had doubtless maintained itself by scraps from the Wild Cat's daily meals."

Rats are extremely prolific, and when living in houses in warmth and plenty, will produce young at every season of the year; but this, of course, does not indicate that any particular female will breed throughout the year. Those who live out of doors and are more poorly fed have a sexual season varying with their circumstances, but coinciding more or less with the warmer six or eight months of the year.[3] Fertility is greatest in countries of mild climate free from extremes of heat or cold, but in exceptional cases winter litters are found even in severe weather in the open country.[4]

Darwin (*Desc. of Man*, ed. 2, 247) was informed that the males are "in great excess," while John Sinclair reported (Thompson, iv., 18) that 75 per cent. of the rats in litters he examined were males. Bonhote, however, found that in Egypt males were apparently fewer than females, constituting only 42 per cent. of those he examined; and of eighty-four examined at Kilmanock, on one occasion, only fourteen were bucks.

Tame female white rats are said to be capable of breeding when five weeks old, and no doubt wild does attain sexual maturity long before they are really full-grown. Shipley states that in Bombay sexual maturity is not reached until the weight is at least 100 grammes.

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[1] Professor Kitasako, quoted by C. Hart Merriam, *U.S. Department Agric. Biol. Survey*, Bull., 23, 1909, letter of transmittal.

[2] *Ibid.*, 10. Much valuable information as to the best means of destroying rats or of protecting property and food from their attacks is given in this paper (pp 36-54).

[3] Heape found the diœstrous cycle to occupy about ten days.

[4] J. C. B. Noble, *Field*, 26th November 1904, 950.

The period of gestation is about twenty-one days,[1] and the number of young in a litter is said to reach thirteen,[2] fourteen,[3] or sometimes twenty;[4] but many litters, especially those of young females, are very much smaller, and sometimes consist of a single young one only.[5] Mr Cocks has records of twenty-three litters[6] of pregnant does examined at Great Marlow and Poynetts; four of these contained 6; ten, 7; three, 8; two, 10; three, 11; and one, 12—giving an average of nearly 8 per litter. In one of 7 the fœtuses were of two sizes; 3, situated at distal end of right horn, being very small. Two litters of 7 and 5 respectively were obtained from a rat with only one ovary.[7]

The young are as helpless at birth as those of other murines, being blind, pink, and hairless, and with the ears sealed down over the auditory meatuses. They are carefully

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[1] J. L. Bonhote, *in lit.*

[2] L. E. Adams, *MS.*

[3] Lantz, *op. cit.*, 15.

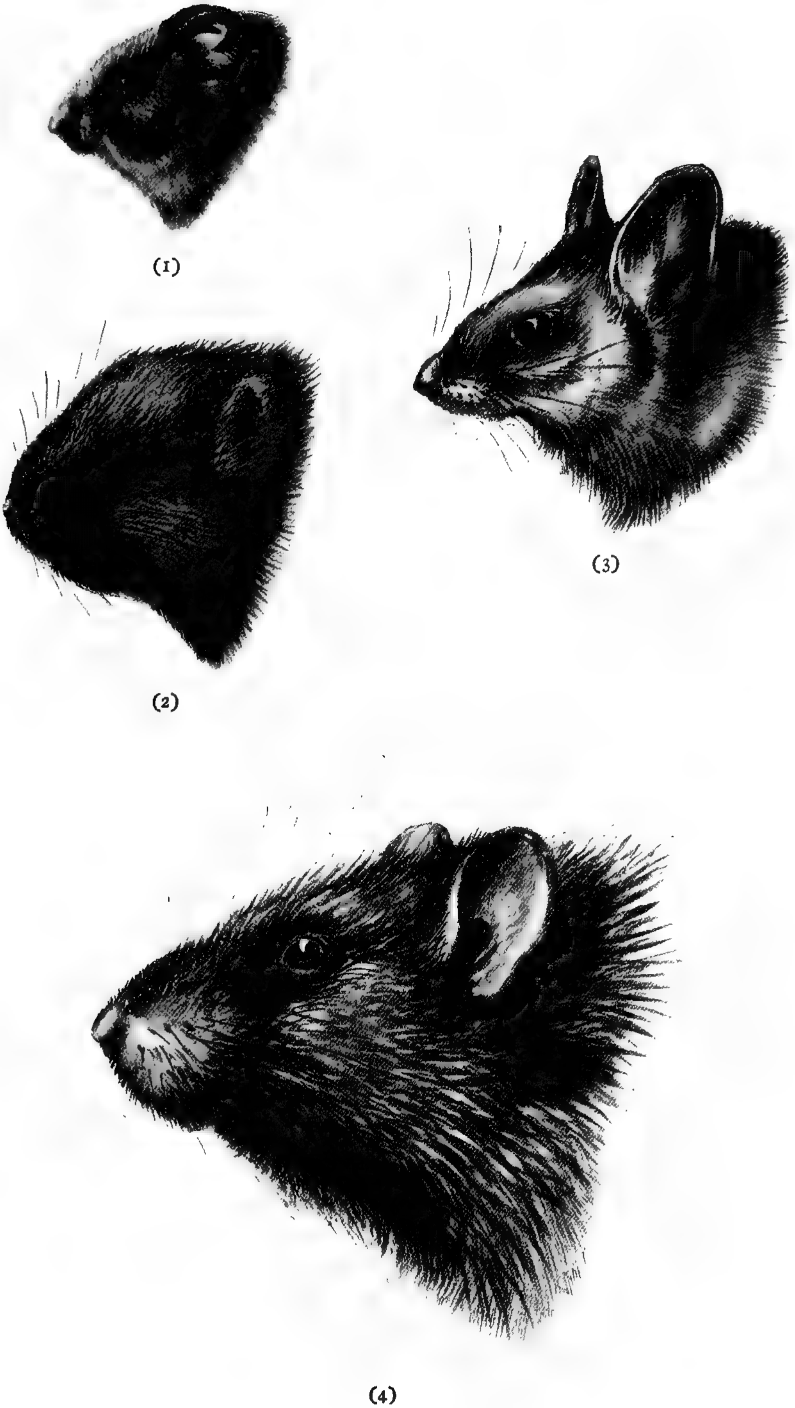
[4] Newton Miller, *Amer. Nat.*, xlv., 623, 1911; C. E. Wright (in Millais, ii., 230) found twenty young in a nest in a mole's fortress in Northamptonshire; C. H. Nash (Adams, *in lit.*) found a double nest containing two old and sixteen young ones, and Owen Jones found thirty-four little rats in one nest. Seventeen and nineteen embryos and twenty-two and twenty-three young in nests are quoted by Lantz from the *Field* (*op. cit.*, 15), but at Bombay the pregnant females of 12,000 specimens examined showed an average of 8·1, and a maximum of fourteen embryos (*Etiology and Epidemiology of Plague*, Calcutta, 1908, 9; and Lantz, *op. cit.*, 15).

[5] Newton Miller (*op. cit.*; and *Nature*, 26th October 1911), experimenting with captive Common Rats, found the period of gestation to vary between twenty-three and a half and twenty-five and a half days; the rats breeding in every month of the year. The female may produce five or six litters annually; the number of young per litter averaging between ten and eleven, and ranging between six and nineteen. One female produced seven litters in as many months, and it was presumed that in cases where all the young perished at birth there would be a dozen litters in the course of the year. The captives devoured 50 per cent. of their young at birth, most, if not all, of these being eaten by the females. Although full growth is not attained before the eighteenth month, sexual maturity is reached in both sexes at least as early as the end of the fourth month.

[6] Inclusive of those published previously in *Bucks* (*Vic. Co. Hist.*).

[7] L. Doncaster and F. H. A. Marshall, *Journ. Genetics*, 1, i., 18th November 1910, 70.

PLATE XXXIV.



HEADS OF BRITISH *Muridæ.*

(1) BANK MOUSE. (2) WATER RAT.
(3) BLACK RAT. (4) COMMON RAT.

tended by their mother alone, who will carry them out of reach of danger, like other rodents, in her mouth.[1] An instance is recorded of a female, caught in a trap by one forefoot, gathering a nest of grass together for her six newly-born young.[2]

Space does not permit a description of the various methods of rat-catching,[3] which, as mentioned on p. 583, is an art of quite respectable antiquity. Black Rats or Common Rats, according to the period, figure quite frequently in Acts of Parliament, churchwardens' accounts, parish registers, and other documents.

Rats are popularly supposed to desert in a body a sinking ship,[4] or a building, when any ruinous injury exists in the masonry. There seems to be no definite evidence of these supposed facts, but unquestionably the movements or migrations of rats are largely governed by questions of food supply.

One generally supposes that rats find their way about by the exercise in an acute degree of the ordinary mammalian senses of sight, touch, hearing, and smell, but some experiments recently undertaken in the biological laboratory of Chicago[5] suggest that they possess a special motor sense of which human beings can have little, if any, cognisance, being independent of sight, smell, or hearing. The whiskers are an important, but not an essential, factor, since, although disturbed temporarily by the removal of the whiskers, the rats were forty-eight hours after the removal perfectly capable of finding their way about without them.

Rats make very attractive and amusing pets.[6] As shown above (p. 617) most, if not all, of the existing domestic breeds belong to the present species. The behaviour of tame *norvegicus* has been well described by Lataste, from whose account the following particulars are largely drawn. They are nocturnal and omnivorous; lying in the nest curled up, the head on chest, and sometimes vertically. They form stores of provisions in their nests, females sometimes stealing the goods of their spouses. Lataste describes it as the most intelligent rodent examined, recognising its owner, licking him and pretending to bite like a puppy; it can be trained to draw up food or drink with a chain, and to count up to four. Wild rats are difficult to tame, being very fierce and intractable, unless taken very young. They are variable in individual character though usually friendly to each other, unless their sense of property be violated. They are prudent without being cowardly, and are much superior in brain to either Black or Water Rats. Although so big and heavy they are still very agile, and Lataste has killed them on the summits of the highest Palms. They swim habitually, although their aquatic powers are very inferior to those of the Water Rat. They are "hard" rats—a fall of 2 metres causing no injury. They never beat with the feet like Gerbillines, but utter cries when battling or coupling; Lataste describes the cry of grief as *sec et désagréable.* The rut lasts only a few hours, and they are more violent in coupling than are tame mice. Gestation lasts twenty-two days, and is apparently unaffected by lactation. A few days before the end of gestation the female prepares a new nest for her family, and later she behaves as an excellent mother. The male kills and devours strange young, but respects those of a female with whom he has coupled; these he regards with seeming indifference—perhaps only on account of the maternal jealousy, for he has been known to help in transporting them when occasion required.

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[1] Eight young were seen thus transported by E. Cowley, *Field*, 18th March 1911, 538; Steele Elliot, *Journ. Birmingham Nat. Hist. and Phil. Soc.*, March to April 1896, ii., 17, saw mouse-sized young similarly transported.

[2] A. B. Hemsworth, *Zoologist*, 1848, 2132.

[3] In addition to the works of Smith and Swaine, cited on pp. 583-584, see Matthew's *Revelations of a Professional Rat-catcher*, 1898; H. C. Barkley's *Studies in the Art of Rat-catching*; James Rodwell's *The Rat: its History and Destructive Character*; Frank Buckland's essay on Rats, *loc. cit. supra*; and other works.

[4] See quotation from *The Tempest*, at p. 578 (Terminology).

[5] *Field*, 27th June 1908, 1117.

[6] Perhaps tamed in Japan first, *vide* Bingley, 253. Some of the Japanese tame these animals, and teach them to perform many entertaining tricks; and thus instructed, they are exhibited as a show for the diversion of the people (Kaempfer's *Japan*, i. 126).

Lataste (373-375) describes the post-natal development. From his account it would appear that at the sixth day the pink colour of the young rat changes, indicating the development of hair. On the tenth day the back is white and covered with fine hairs of 1 mm. in length; at the fourteenth day the eyes open, and on the sixteenth day the perforation of the outer ear appears. On the seventeenth or eighteenth day the young commence to leave the nest and eat—they are very lively. At the twenty-third day their white coat begins to attain the yellowish tints of the adults; they incessantly run, jump, and climb. By the twenty-sixth day, and sometimes even by the twenty-first or twenty-second day, they can leave their mother, but if with her they may suckle to the twenty-eighth day. The young have extraordinary vitality: one—only two days old—lived after forty-eight hours' exposure in September to the external air on a metal plate (Lataste, 344 and 374).

Rats have a considerable development of voice, frequently squeaking loudly; Johnston (240) describes one as uttering a thin metallic "skikking" sound when angry, or a grunting, murmuring noise when amorous.

Genus MUS.

1758. MUS, C. Linnæus, *Syst. Nat.*, 10th ed., i., 59; genotype, by tautonymy, *Mus musculus* (G. S. Miller, *Proc. Biol. Soc.*, Washington, xxiii., 19th April 1911, 59); in part of most authors.

1814. MUSCULUS, Rafinesque-Schmaltz, *Précis des Découv. et Travaux Somiologiques*, 13; a substitute for *Mus*.

1837. LEGGADA, J. E. Gray, *Charlesworth's Mag. Nat. Hist.*, i., 586; genus for *L. booduga*, Gray.

1842. MICROMYS, Lesson, *Nouveau Tableau, Mamm.*, 139.

1845. DRYMOMYS, Tschudi, *Fauna Peruana*, 178; based on *D. parvulus*, Tschudi = *Mus musculus*, Linnæus (see Thomas in Palmer, *Index Gen. Mamm.*, 246, 1904).

1876. NANNOMYS, W. Peters, *Monatsber. k. preuss. Akad. Wiss.*, Berlin, 480; based on *N. setulosus*, Peters.

1881. ACROMYS, E. L. Trouessart, *Bull. Soc. d'Études Sci. d'Angers*, x., 133; a synonym of *Drymomys*, Tschudi.

1896. PSEUDOCONOMYS, Rhoads, *Proc. Acad. Nat. Sci.*, Philadelphia, 531; subgenus based on *Mus (Pseudoconomys) proconodon*, Rhoads, from Western Somaliland.

1900. DRYOMYS, Philippi, *An. Mus. Nac. de Chile*, xiv., 20; a modification of *Drymomys*, Tschudi.

As now defined, the genus *Mus* is restricted to the House Mice and their allies; these, according to Miller, comprise about twenty-five distinct forms, of which seven are represented in western Europe.

This is a perfectly natural group enjoying a wide natural distribution in southern Asia and in Africa, and having no near relationship with any other genus, except the Indian *Leggadilla*, which may be regarded as an offshoot. The genus betrays a high degree of specialisation, and as regards its dental characters it undoubtedly stands on a loftier plane than does any of the other members of the sub-family dealt with in this work.

Externally this genus does not differ noticeably from *Epimys*, but all the known species of *Mus* are of small size. The females have ten mammæ, arranged in three pectoral and two inguinal pairs.

In the **skull** the brain-case is rather small and depressed; there are no interorbital beads (present in *Leggadilla*), and the temporal ridges of the brain-case are very feebly developed; the zygomatic arches are relatively strong, particularly as regards their anterior maxillary portions, and there is a small peg-like process on the outer side of each maxilla below and just in front of the lower zygomatic root, which serves for the attachment of the tendon of the anterior part of the *masseter lateralis* muscle.

In the **dentition** the upper incisors are strongly curved, terminating behind in the maxilla between m^1 and the maxillo-premaxillary suture. The disc of wear is peculiar, there being a well-marked notch on the outer side just behind the junction of the white dentine with the yellow enamel. Winge explains this feature by supposing the dentine to be harder at the postero-external corner of the tooth than elsewhere; Miller, on the other hand, attributes it to the angle at which the teeth are set. We are not able to find any appreciable difference between *Mus* and *Epimys* as regards the "set" of the incisors, and would attribute the notch rather to the increased strength and peculiar mode of action of the *masseteres laterales* muscles, which have induced several much greater modifications in the structure of the cheek-teeth as well as in the skull itself.

The lower incisors terminate behind, near the bases of the condylar processes, their ends producing rather well-marked humps on the outer surfaces of the mandible.

Cheek-teeth (Pl. XXVIII., Fig. 10):—In this genus $m\frac{1}{1}$ are relatively large, being as long as or longer than $m\frac{2-3}{2-3}$

together. The median tubercles, x, y, and z are very largely developed. In m^1 the laminæ are conspicuously bowed, cusp x' lying distinctly behind x and in line with cusp y, cusp 6 being similarly in line with z; cusps 1, 4, and 5 are large, and clearly separated from the median tubercles; and there is no trace of either cusps 3 or 7. In m^2 cusps 4 and 5 are more reduced than in m^1, being more intimately connected with cusps y and z than in the latter tooth; cusp 1 is represented solely by a minute vestige at the base of the crown, or it may be wholly lacking; cusps x' and 6 are largely developed, the latter being in line with z as in m^1. The last molar above is very small, and consists of a large cusp x' and a postero-external tubercle, which appears to be a compound of cusp y and other elements. In some species m^3 consists of one tubercle only. In the lower molars the median tubercles y and z are so greatly enlarged that all trace of the primitive outer row of cusps (6, 7, and n) is obliterated. In m_1 cusp z' is relatively small, and there is no trace of an anterior median "accessory" tubercle; the posterior "accessory" (cusp 1) is well developed in this tooth and in m_2; m_3 consists of three cusps, viz., z and 5 in front, and a tubercle compounded of y and 4 behind.

The relatively large size of $m\frac{1}{1}$ in the genus appears to be a consequence of the increased strength of the masseter muscles; the anterior tooth is most favourably placed dynamically, and it therefore takes a larger share of the work of mastication. The hinder teeth $m\frac{2-3}{2-3}$ have become of less functional importance; they are therefore reduced in size, and $m\frac{3}{3}$ tend to disappear. In South American specimens the latter teeth are frequently lacking, either wholly or from one or the other jaw (see p. 649 below).

Nothing is definitely known of the **geological history** of this genus. It has been recorded from the British Pleistocene on several occasions; whilst most of these records seem to have been based on error, it is just possible that one or two of them may be well-founded.

THE HOUSE MOUSE.

MUS MUSCULUS, Linnæus.

1758. [Mus] MUSCULUS, C. Linnæus, *Syst. Nat.*, 1, 10th ed., 62; described from Upsala, Sweden; of most subsequent authors.

1772. Mus DOMESTICUS, J. Rutty, *An Essay towards a Nat. Hist. of the County of Dublin*, i., 281.

1801. M[us] M[USCULUS] ALBUS, FLAVUS, MACULATUS, and NIGER; J. Bechstein, *Gemein. Naturgesch. Deutschlands*, ed. 2, i., 955; described from Thuringen, Germany.

1827. [Mus MUSCULUS] STRIATUS, ALBICANS, and NIVENS, Billberg, *Syn. Fauna Scand.*, 6; described from Skåne, Sweden.

1867. [Mus MUSCULUS] HELVOLUS, VARIUS, and CINEREO-MACULATUS, L. Fitzinger, *Sitzungsber. kais. Akad. Wiss. Wien.*, *math.-nat. Cl.*, lvi., Abt. i., 70; *helvolus*, described from Hungary, *varius* and *cinereo-maculatus* from Europe.

1869. Mus POSCHIAVINUS, V. Fatio, *Faun. Vert. Suisse*, i., 207; described from Poschiavo, Grisons, Switzerland; as sub-species, Trouessart.

1872. Mus MUSCULUS, var. FLAVESCENS, Fischer, *Zool. Garten*, xiii., 223; described from Berlin, Germany.

1907. Mus NUDOPLICATUS, Campbell, *Zoologist*, 1; described from living specimens received from Australia.

1912. Mus MUSCULUS MUSCULUS, G. S. Miller, *Catalogue Mamm. West Europe*, 871.

Die Hausmaus of the Germans; *la souris* of the French.

The **synonymy** given above has reference only to the House Mouse in Europe; many other names, based upon material collected in the East or in America, have been applied to this animal, but it is not necessary to deal with them here.

The House Mouse is "*Mus domesticus*" in Albertus Magnus (*de Anim.*, xxii., fol. 182), Gesner (*de Quad.*, 1551), Jonston (*Quad.*, 115, t. 66, 1657), and Merrett (*Pinax*, 167, 1667); "*Mus domesticus minor*" in Aldrovandus (*Digit.*, 417); "*Mus domesticus vulgaris seu minor*" in Sibbald (*Scot.*, 12, 1684) and Ray (*Syn. Quad.*, 218, 1693); "*Mus minor*" in Klein (*Quad. disp.*, 57); it is "*Sorex domesticus*" in Charleton (*Exercit.*, 25, 1677), and "*Sorex*" in Brisson (*Reg. Quad.*, 1762, 119), and Gronovius (*Zoophy.*, 1, 4, n. 19).

Terminology:—Variants of the word "mouse" (derived from the Sanskrit *mūš* and the Greek *μῦς*) are common to all the Teutonic and Indo-Germanic languages, and were used, like the Latin *sorex* and the Celtic *luch*, indiscriminately for all small, mouse-like rodents and insectivores. The House Mouse being the most familiar of such creatures, the word was at an early date specially applied to this species, without, however, losing its more general significance. The earliest instances of such special usage of "*mus*" and "*mys*" in English, cited in the *N.E. Dictionary*, are in King Ælfred, *Boeth.*, xvi., 2 (about 888), and in *Lamb. Hom.*, 53 (about 1175); in the latter it is stated that "*þurh y^e sweote smel of y^e chese he bicherred monie mus to y^e stoke.*" Derivatives of "*sorex*," as the French *souris*, similarly acquired a secondary, restricted meaning, and came to denote the present species. In ancient times, as mentioned on p. 578 above, the word "*rat*" also was perhaps used for the House Mouse in western Europe.

The mouse of course figures in many familiar expressions of ancient origin; thus, "drunk as a dreynt (= drowned) mouse" is met with about 1310 (Wright, *Lyric P.*, xxxix., iii.) and in Chaucer (*Wife's Prol.*, 246); "quiet as a mouse" starts in 1599 in Porter (*Angry Women*, 184, 71), and "wrecched mouses herte" occurs in Chaucer (*Troilus and Creseide*, iii., 736). *Mouse-traps* are mentioned in *circa* 1475—*Cath. Angl.*, 245/1 (MS. addit.).

In technical writings this species is usually the "Mouse" or "Common Mouse," as in Pennant (*Brit. Zool.*, i., 108, ed. 1776; *Hist. Quad.*, ed. 3, ii., 184). "Domestic Mouse" appears in Macgillivray (250). "House Mouse" was apparently first used technically by Jenyns (*Man.*, 31, 1835), and is to be preferred to "Common Mouse," generally used in books, since our dwellings form the chief station of the species in Britain, while out of doors its numbers are far inferior to those of the Field Mouse.

Local names (non-Celtic):—"Rick Mouse" and "Barn Mouse" (the latter in Scotland) are names used for some outdoor mice, "larger and darker than the House Mouse" (Tomes in Bell, ed. 2, 300).

(Celtic):—In the Celtic languages it is called simply "*luch*" (Scotch and Irish Gaelic) or "*llygoden*" (Welsh)—these names being used with or without distinctive epithets for most other "mice" as well.

History, distribution, and status:—Although in all probability the House Mouse is of Asiatic origin, we possess no decisive or very clear evidence on this point. Its arrival in Europe must date from a very remote time, for the animal was well known to the ancients: it is definitely referred to by Aristotle (*Hist. Anim.*, i., c. 2, 15) and Pliny (*Hist. Nat.*, viii., c. 56); numerous references to it by Greek writers are quoted by Rolleston (*Journ. Anat. and Phys.*, 1868, 47). Early mediæval writers on natural history, as Albertus Magnus, had exact knowledge of it, and many references to it are of course to be found in our own literature; some of these are quoted above under Terminology, and in the article on the Black Rat (p. 578). Donovan (xxxviii.) thought it native, because it is mentioned in the *Leges Wallicæ* more than ten centuries ago.

It arrived in North America shortly after the first settlement of Europeans there, and is now distributed in all the settled parts of the New World; being scarce, however, in the extreme north, because it does not always survive the winters (Lantz, *op. cit.*, p. 11).

This species owes its present almost universal distribution to its success as an invader and colonist of human dwellings and store-places, and to subsequent accidental transport with human commerce. In cool climates, although often found living out of doors, it is rarely met with far from houses or other scenes of human activity. But in countries where the climate is suitable and food readily obtainable, as in many of the warmer parts of America, it has resumed a free or natural station, and competes successfully with the indigenous rodents. In such situations it, like other murines, shows an inherent plasticity, enabling it to develop races modified in one way or another to meet the peculiar requirements of a foreign environment.

Distribution in time:—The remains of "mice" recorded by Buckland (*Rel. Diluv.*, 19, 265, pl. xi., figs. 7-9) from the Kirkdale Cave were probably remains of *Apodemus;* the figured jaw agrees in size with that of the Field Mouse, and the rather inaccurate drawing of the cheek-teeth might represent teeth of that species quite as well as those of the House Mouse. Owen (*Brit. Foss. Mamm.*, 209, fig. 79) also figures a jaw from Kirkdale; this drawing, as regards the teeth and form of the jaw, agrees better with the House Mouse, although the size is rather large. The species is listed from Kent's Cavern and the Durdham Down Cave, by Morris (*Cat. Brit. Foss.*, 1854, 360) and Boyd Dawkins (*Q.J.G.S.*, xxv., 198, 1869); it has also been doubtfully recorded from the Pleistocene of Copford by R. Bell (*Proc. Geol. Assoc.*, ii., 217, 1871). It has been stated to occur in the Pleistocene deposits of the Thames valley (see Lydekker, 189). Although we have had the advantage of studying a far greater number of British fossil mouse remains than has any other observer, we have never met with the slightest trace of this species among them; we are, therefore, inclined to doubt the identifications in some cases, and to think in others that the remains were comparatively recent introductions in the deposits whence they have been recorded.

Description:—The House Mouse is a slenderly built, rather sharp-faced murine of medium size (head and body, 75 to 100 mm.; hind foot, 17 to 19·4; condylo-basal length of skull, 19·8 to 22·4 mm.), with the tail about as long or longer than the head and body, clad with soft fur, and usually of a brownish-grey colour.

The **eyes** are small, and somewhat protruding, although much less prominent than in the Field Mouse. The broadly ovate **ears** are of moderate size, their length being about half that of the head, and they cover the eyes when laid forwards; save for the naked internal basal portions, they are thinly clothed within and without, with short and fine hairs; in each the meatal valve is represented merely by a low ridge placed just behind the meatus.

In each **hand** the thumb is a vestigial tubercle, scarcely exceeding one of the palmar pads in size, and bearing a small flattened nail; digit 3 is the longest finger, digit 4 being very slightly shorter; digit 2 is slightly shorter than digit 4, and digit 5 reaches a little beyond the base of digit 4. The five palmar tubercles are small, occupying less than half of the surface of the palm; the three anterior are small and round, the external one having a small additional free tubercle by its outer side at the base of digit 5; the posterior pads are larger and oval. Between the pads the skin is irregularly wrinkled and granular; the ventral surfaces of the digits have annular scales which tend to be interrupted in the middle.

The **feet** compared with those of the Field Mouse are shorter and broader, and each has the usual six pads. The latter are relatively small, and widely spaced, of oval or rounded form, and differ but little from each other in size—the two anterior being slightly the largest, the postero-external slightly the smallest. In addition, a little free supplementary tubercle is developed to the outer side of the pad at the base of digit 5, and there is a similar tubercle to the inner side of the pad, at the base of the hallux. The skin between the pads is wrinkled, but smooth towards the heel. The hinder part of the sole is hairy along the edges, and solitary hairs are scattered between the pads. Digits 2, 3, and 4 are the longest, 2 and 4 being slightly shorter than 3; digit 5 reaches a little beyond the base of digit 4, and digit 1 extends as far as the base of digit 2. Both the fingers and toes (including the hallux) are armed with small, simple, curved claws, those of the toes being slightly the longer.

The **tail** is usually about as long as, or a little longer than, the head and body; it is finely annulated with about 180 scaly rings, the boundaries of the individual scales being somewhat indefinite; it is clothed with numerous short, stiff hairs, each equalling in length the width of about two and a half annulations; the hairs do not, however, conceal the rings, and they do not form a terminal pencil.

The **fur** is soft throughout, longer, and denser on the back; shorter, thinner, and rather closely adpressed on the belly; grooved bristles occur as in the rats, but they are so slender as to produce no sensible effect upon the quality of the pelage. The microscopic structure of the hair is described below under *Pigmentation and Inheritance.*

Colour:—The general colour of the upper parts is a dusky grey, irregularly darkened with slate and black along the middle of the back, and paling gradually to ashy grey on the flanks and belly. The hairs have slaty bases, appearing on the surface in the region of the chin and throat, and dusky tips; their subterminal bands are yellow, and these produce a more or less well-marked tinge of yellow above and below. The ears are of a dull brownish colour, their antero-external edges being usually darker than the other parts. The feet are dusky above, and do not afford any noticeable contrast with the general tint of the back. The tail is usually dull brown, both above and below, but sometimes the under surface is slightly the paler.

The **young** in first pelage hardly differ from the adults in general colour; their coat is a little softer and closer, consisting chiefly of the woolly underfur.

The **skull** (Fig. 93) compared with that of the Field Mouse is disproportionately small and peculiarly flattened. In correlation with the small size and weight of the brain (see p. 566 above), the broadly ovate brain-case is depressed, its depth being relatively little greater than that of the rostrum. The interparietal is large and rectangular, and it belongs wholly to the occipital region, the lambdoidal crest and suture passing in front of, instead of behind it, as in *A. sylvaticus*. The interorbital region is broader than the rostrum; its edges are square and not beaded, and the temporal crests, which are their backward continuations on the sides of the brain-case, are very feebly developed. The zygomatic arches are relatively strong, and their greatest breadth usually falls just in front of the glenoid articulations; the vertical anterior border of the masseteric plate is situated distinctly in advance of the roof of the infra-orbital canal, and at its base there is a quite small, but prominent peg-like process, from which the tendon of the anterior part of the masseter muscle takes its origin. The incisive foramina are greatly narrowed behind; they are of remarkable length, and terminate posteriorly about opposite the middle of m^1. As in *Micromys*, the palatal shelf extends backwards behind the tooth-rows for a short distance; in this region it shows also a slight median ridge, which is frequently channelled by a weak longitudinal ventral groove. The mesopterygoid fossa is of moderate length, wider behind than in front, where it terminates squarely. The pterygoids are straight, and their hamular processes barely meet the moderately large auditory bullæ. The nasals extend forwards but little in advance of the front faces of the incisors.

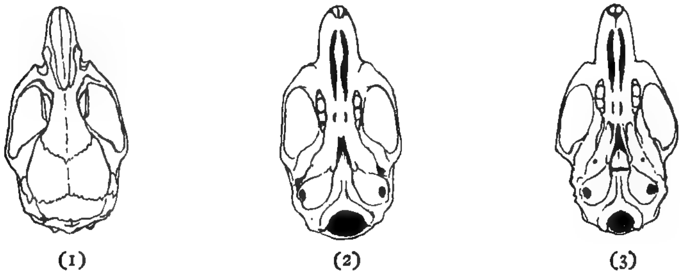
(1) (2) (3)

FIG. 93.—SKULLS OF *Mus musculus* (1) dorsal, (2) ventral; AND *Mus muralis* (3) ventral; × 1½.

The **mandible** is slightly shorter and deeper relatively than in the

Field Mouse; the strongly recurved coronoid processes rise slightly above the level of the condyles.

The **teeth** have been described above under the genus.

Local variation:—The yellow subterminal bands of the longer hairs are usually better developed in outdoor House Mice, which, therefore, have a more sandy appearance than those generally caught in houses. This fact has long been known, as, to Macgillivray, who states (251) that "individuals obtained in the fields are sometimes almost as beautifully coloured as the Wood Mouse, there being much yellowish-brown on their upper parts, and their lower being of a dull cream-colour"; and to Jenyns, who adds (*Man.*, p. 32) that they "sometimes attain a larger size, measuring nearly four inches in length."

The mice described by Jameson (*Journ. Linn. Soc.*, xxvi., 1898, p. 465) from the sandhills of the North Bull, Dublin Bay, though differing among themselves, are characterised by their very light colour, and may be regarded as representing the extreme phase of the yellow outdoor coloration; these mice live on a barren sandy waste, where they are exposed only to the attacks of enemies hunting by sight alone; therefore, as suggested by Jameson, it is not unlikely that natural selection has played and is playing an important part in the elimination of the darker individuals of the colony.

Adams[1] (*MS.*) has caught tawny bellied House Mice in Surrey and Sussex; these were taken usually in cornfields and hedge-banks—often 300 or 400 yards from any building, sometimes in ricks at threshing, and once or twice in country houses. He notes that the tails were often relatively longer than in indoor House Mice. A few years ago W. Evans observed that the House Mice living out of doors on the Isle of May (Firth of Forth) were lighter in colour than ordinary indoor examples; he sent one of these to Barrett-Hamilton. It seems probable that the original colour of wild *M. musculus* was some shade of yellow or tawny; and that in this case, as Adams suggests, the tawny hue of present outdoor families may be explained either as a reversion to type, if such families have descended from a domestic stock, or as a retention of the ancestral coloration, if they have always been feral. In either case the difference between the indoor and outdoor coloration, whatever its "protective" value may be, is probably to be explained as a result of the wide difference in the light intensities to which the two stocks are respectively exposed.

Kinnear (*Ann. Scott. Nat. Hist.*, 1906, 65) describes the House Mice of **Fair Isle** as being rather larger and more tawny in colour than mainland mice; they are said to be very numerous among the crofts, but after the corn is cut they betake themselves to the houses.

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[1] Adams (*MS.*) "noticed very markedly in the sunny summer of 1911, that the coats of the Common Shrew were lighter in colour than usual. There was much more albinism in ears than usual—about 25 per cent. had white ears in that year, whereas about 4 per cent. is the normal condition."

The House Mice from Braescleit and Barvas, western **Lewis**, differ in no way from ordinary *musculus* (W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1908, 198; Hinton and Hony, *The Scottish Naturalist*, 1916, 221). From fields at the Butt, or northern extremity, of Lewis, Eagle Clarke, however, obtained specimens which approach *muralis* in their large size, but do not differ from *musculus* in coloration or in skull structure.

On **North Uist** ordinary House Mice, and others which are practically identical with *muralis* in size and colour, though slightly paler below, occur quite commonly in the houses at Lochmaddy. Intermediates between the two forms have not been observed, and although the only but imperfect skull seen seems to agree better in form with that of *musculus* than with that of *muralis*, it is not impossible that the variety may be a second form of the latter species (Eagle Clarke, *op. cit.*).

A youngish female from **Islay** has the whole ventral surface of a beautiful clear white, separated by sharp lines of demarcation from the flanks, which are but slightly lighter than the back, the general dorsal colour approaching that of *Apodemus* (Hinton, *Ann. Mag. Nat. Hist.*, July 1914, 130, and June 1915, 583). Specimens from **Skye**, and a male from **Tiree** (*Proc. Zool. Soc.*, 1913, 835) trapped in sand-hills, represent the yellowish outdoor form, while one obtained by Mr Kinnear in **Barra**, from a hole in a field, is of normal indoor appearance.

Specimens obtained for Ogilvie-Grant from Hermaness Hill, **North Unst**, **Shetland**, in the autumn of 1914, are remarkable merely for their relatively stout tails.

Exceptional variation:—Quite apart from the well-known differences in pattern and colour presented by the tame "fancy" breeds, the House Mouse shows many individual or family variations, particularly in its coloration and pelage. Such variations have formed the bases of most of the specific or sub-specific names enumerated in the synonymy above.

True albinos, wholly white or cream-coloured with pink eyes, partial albinos, white specimens with dark spots, dark specimens with light spots, and melanistic examples, are not rare. Fatio's *M. poschiavinus* was based, with much hesitation, on a Swiss melanic race.

Tomes (in Bell, ed. ii., 296) describes a great number "killed in a wheat-rick at Welford-on-Avon, which were of a light grey colour, without the least mixture of brown," and Collett (165) speaks of a similar variety in Norway. In another rick at Welford Hill, Tomes found all the mice to be "of an unusually dark colour, especially along the dorsal line, which was nearly black"; this latter form is apparently that to which the names "Rick Mouse" and "Barn Mouse" are applied (Tomes, *op. cit.*, 300), and which occasionally, though not always, attains an unusually large size.

Several specimens of a pale buff or cream variety were sent to W. Evans from Lyne, Peebles, where they occurred in some abundance, in April 1890.

Varieties with long, black, silk-like hair (W. P. Cocks, *Rep. R. Cornwall Polytech. Soc.*, 1852, 59); naked, with corrugated skin (a few whiskers present), and producing similar young (Bateson, *Variation*, 56); partially naked and smooth-skinned (?disease or parasites; Gordon, *Zoologist*, 1850, 2763) have been recorded. Cocks (*Bucks* and *Zoologist*, 1903, 420) mentions an epidemic of blind and partially blind House Mice captured during a succession of years in one locality.

Pigmentation and inheritance:—When examined microscopically, under a low power, the hairs of the back are seen to be of three kinds, although all have slender bases and fine distal, terminal points. Some (Fig. 94) are short and fine, constituting the underfur. Others are of medium length, flattened and broadly expanded centrally; these apparently correspond with the spines found in the fur of rats. Lastly, many are very long and show two or three expanded tracts alternating with contracted portions (Fig. 94)[1]; the terminal expansion of these hairs is usually bright yellow in colour, but the fine tips together with the lower portions are black or dusky. To these longer hairs the general colour is due. The belly is clothed only with the short hairs of the underfur.

The minute structure of the hairs is, as in many other rodents, of a remarkably complex type. Each hair consists as usual of an outer sheath or cortex of kerotin investing a central medullary cavity; when highly magnified, the latter is seen to be divided into compartments by slender bridges of kerotin. At the base of a hair the bridges are transverse and the compartments simple; but in the broader parts, and particularly in the "spines," the bridges acquire an oblique direction, and send forwards and backwards outgrowths of kerotin which join similar processes from the contiguous bridges; by this means in such places the transverse medullary compartments are divided into two, three, four, or five separate secondary chambers (Fig. 94). The number of secondary chambers to a transverse compartment increases as the hair expands, and diminishes again as it tapers distally.[2]

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[1] Douglas English describes and figures similar alternately contracted and expanded hairs in the Shrew (*Some Smaller British Mammals*, 66).

[2] This structure attracted attention in the earliest days of microscopy. Thus Shaw (*General Zoology*, ii., Pt. 1, 57, 1801) describes the hairs as "appearing internally divided into a kind of transverse partitions, as if by the continuation of a spiral fibre." He further cites Derham (1657-1735), who, in his *Physico-Theology*, conceived that this mechanism of a spiral fibre may serve for the "gentle evacuation of some humour out of the body," and added that "perhaps the hair serves as well for the insensible perspiration of hairy animals as to fence against cold and wet."

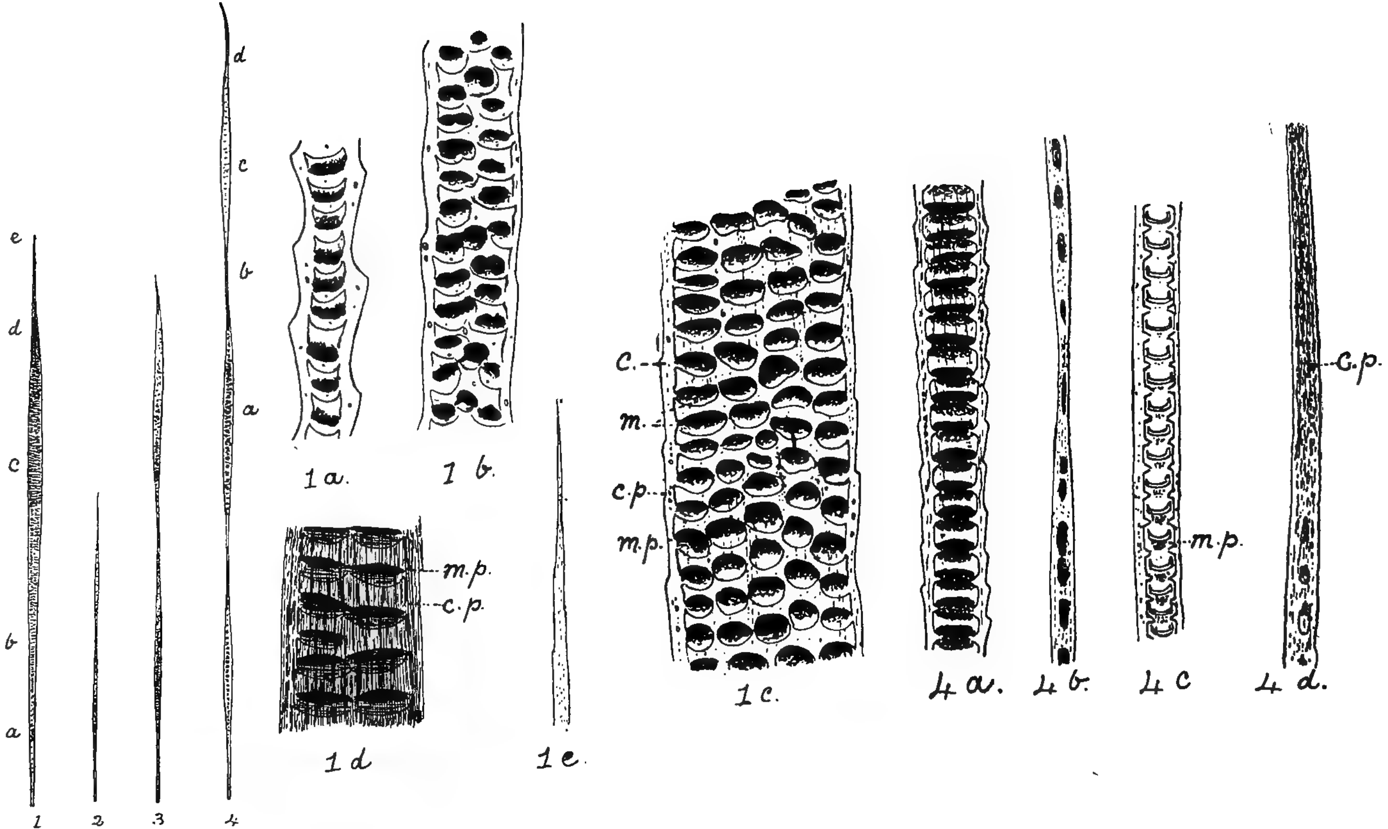

FIG. 94.—HAIRS FROM BACK OF HOUSE MOUSE: (1) Spine; (2) short hair; (3) long hair, with one central contraction; (4) long hair, with two central contractions (enlarged, width exaggerated). 1*a-e* and 4*a-d*, camera lucida drawings of the correspondingly lettered portions of the hairs shown in Figs. (1) and (4); as printed, the magnification equals 570 diameters, but the structure represented is that seen with a magnification of 960 diameters. In these drawings, *c*=cortex; *m*=medullary cells; *c.p*=cortical pigment; *m.p*=medullary pigment.

Some of the medullary chambers contain air only, but in the majority, pigment granules occur as well. The pigment present varies in amount, from a few isolated granules to thick clusters adhering to one or other of the walls of the medullary chamber, and almost filling its space. The medullary pigment of the "spines" and of the lower parts of the other hairs is usually black and opaque; but a few granules are dark brown, and to some extent translucent. The base of the hair and many tracts of the cortex are clear and devoid of pigment. In other places, as at the expansions, and especially towards the distal contractions, the cortex contains many scattered pigment granules, which are occasionally arranged in two or three little longitudinal and closely approximated rows. The cortical pigment of the longer hairs is usually dark brown in their lower portions, but at these deep levels a few yellowish granules may occasionally be seen.[1]

As mentioned above, the terminal segment of a long hair is usually yellow except towards its tip, where the medullary pigment is absent and the abundant dark cortical pigment gives a dusky hue. On carefully examining such a hair segment, it is frequently possible to observe, firstly, that the medullary pigment is rather darker (brownish) proximally, but becomes gradually lighter to golden or translucent yellow distally; and secondly, that the cortical pigment shows a similar transition at the corresponding levels.

Colour is now regarded by many[2] as resulting from the oxidation of a chromogen by the action of a ferment; the tint produced depending partly upon the nature of the chromogen and partly upon the degree to which it is oxidised. The results of our work, confined as it has been to a careful microscopic examination of the hairs of mice and many other mammals, lead us to think that the transition from black pigment through brown to yellow is a gradual one, and that it may well be the result of progressive oxidation. The gaseous contents of the medullary chambers perhaps play a part in this process, and the dark hue of the cortical pigment of the hair tips may be due to the fact that the medullary space dies out before reaching the hair tip.

The local attenuations of the longer dorsal hairs of the House Mouse probably assist in the coat change. The distal yellow segment of the hair breaks off in due course at the contraction next below it; this contracted part becomes the new hair tip, and as growth pushes it

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[1] For another account of structure of hairs and distribution of pigment in House Mouse, see Durham, in Bateson, *Proc. Zool. Soc.*, 1903, ii., 72.

[2] For further information on the chemistry of colour, see—Cuénot, *Arch. Zool. Exper. et Gén.*, *Notes et Revue*, 1, xxxiii.; Durham, *Proc. Roy. Soc.*, 74, 310, 1904, and *Journ. Physiol.*, 35, May 1907; Mudge, *Journ. Physiol.*, 38, March and Oct. 1909, and *Nature*, 14th April 1910, 18; Sollas, *Nature*, 24th March 1910, 96; Forbes, *ibid.*, 21st April 1910, 217; Wheldale, *Prog. Rei Botanicæ*, iii., 457, 1910; Onslow, *Proc. Roy. Soc.*, B 1915, 36.

up the dark pigments of its segment in turn gradually oxidise and become yellow. In some "voles," e.g., *Microtus orcadensis* (see p. 458 above), a similar process appears to take place occasionally.

Extensive researches upon the **inheritance** of the coloration, coat pattern, and of some physical defects in the House Mouse, have been made by the Mendelians. The literature relating to this work has become quite voluminous, and no more than a mere outline of the broader results can be attempted here. The experiments have mostly been made with tame "fancy" mice, but these have been crossed from time to time with wild animals. The various conditions investigated have been proved for the most part to depend upon the presence or absence of certain definite factors, and to obey Mendel's law in inheritance. In the following paragraphs the capital initial signifies the presence of a factor as opposed to its absence, denoted by a small initial; in general, *X* is dominant, *x* recessive.

As regards *pigmentation*, a considerable number of factors appear to be involved. Colour is produced by a special factor, *C*, and if this be absent (*c*) the mouse will be an albino even if it carry all of the other pigment factors. The depth of the coloration depends upon another factor, *D*; when this is present with *C*, the pigment granules are developed in full number, and the colour is intense or saturate; in its absence (*d*), there are fewer granules and the colour is dilute. The precise hue of the mouse depends upon a large number of factors, known as "colour determiners"; these determiners stand apparently in a certain definite relation to each other. When all the normal determiners are present, together with *C* and *D*, the animal is in appearance an ordinary wild House Mouse, grey or "agouti" in colour. Should the grey determiner (*G*)[1] be lacking, and the black (*B*) and chocolate (*Ch*) determiners be both present, the mouse will be black—the determiner *B* masking the determiner *Ch*. To be chocolate in colour the mouse must not only carry *Ch*, but it must lack the determiners *G* and *B*. Grey cannot, however, be called dominant to black, because these factors belong to different allelomorphic pairs, and Bateson, therefore, introduced the terms "*epistatic*" and "*hypostatic*" to express the relationship of the different colours; thus, in relation to black (*B*), grey (*G*) is epistatic, while chocolate (*Ch*) is hypostatic.

The combined researches of Cuénot, Durham, Castle and Little, Hagedoorn, and others, have shown that yellow mice belong to two entirely distinct groups, namely:—(1) that in which yellow arises by means of the suppression of the chocolate determiner (*Ch*); and (2) that in which the yellow colour is due to the presence of a definite yellow determiner.

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[1] Strictly, there is no "grey determiner" at all, there being no grey pigment in mice. The grey colour is produced by "barring and ticking," *i.e.*, by the orderly arrangement of the three pigments, black, brown, and yellow, in each hair in definite bands of restricted extent. This arrangement is brought about, according to the Mendelians, by the presence of a special factor (or pair of factors, according to Hagedoorn) called the "grey determiner" above.

Yellow mice of the first type were studied by Hagedoorn, who proved that all mice lacking the chocolate determiner are some shade of yellow; that in such mice, if the determiners for grey (*G*) and black (*B*) are present, the mouse appears as a "yellow agouti," while it is "tortoise" if the black determiner alone is present. This group is apparently strictly comparable with the yellow forms of rabbits and cavies, in both of which, as here also, yellow shows itself to be hypostatic to black and grey. Mice homozygous for *ch* are readily produced when once a culture lacking *Ch* has been obtained.

Much greater interest attaches to the second group of yellow mice. These were first studied by Cuénot, and afterwards by Miss Durham, Castle and Little, and still more recently by Hagedoorn. Here the yellow colour is due to a yellow determiner, called *I* by Hagedoorn, which shows itself to be epistatic to grey and black, and which is quite unknown in wild House Mice. No one has so far succeeded in obtaining homozygous yellow (*II*) mice, although large numbers have been bred; such yellows are always heterozygous (*Ii*), and when mated together, as Castle and Little have shown, they produce yellow and non-yellow young in the ratio 2 : 1 instead of 3 : 1, as would be expected by the application of ordinary Mendelian principles. According to Castle and Little it would seem that a whole class, viz., that of the homozygous yellows (*II*), is absent from the progeny; not because yellow ova fail to be fertilised by yellow spermatozoa in due numbers, but because the homozygous germs so produced perish soon after they are formed, having apparently some physiological inability to develop further. Cuénot, Miss Durham, and Castle and Little all found evidence (smaller litters and a greater liability to sterility) of diminished fertility in these yellow mice, while the frequent tendency of such animals to become excessively fat is well known. These facts afford strong grounds for the presumption that the introduction of the yellow determiner (*I*) gravely deranges the physiological equilibrium of the individuals carrying it. The question as to how this strange determiner has been introduced is quite unsettled; the most plausible explanation yet offered is that it has been brought into the breeds showing it by means of hybridisation with some other species at present not identified. Bateson, on the ground of a claim by a well-known breeder of mice to have made such a cross, thought that there might have been a cross with the Field Mouse. However improbable this view may be, it cannot be dismissed without further experiment, because, apart from the old statement made by Melchior, cited on p. 552 above, Hagedoorn states that, although the species do not mate together naturally, he succeeded in impregnating, by artificial insemination, a female *M. musculus* by a male *Apodemus sylvaticus;* unfortunately, the mouse either aborted or else ate her young. As Hagedoorn points out, it is quite possible that if the determiner *I* came originally from another species, that other species may not have been a yellow animal at all. We are inclined to think that in connection with this problem Mendelians might profitably try to cross *M. musculus* with *spicilegus*, or one of the other truly wild species of *Mus.*

Albinism results either from the absence of the colour factor (*C*), or from the absence of all the colour determiners. Albinos lacking *C* may lack all the colour determiners also, or they may carry certain of or all the colour determiners, either in a dilute or a saturated condition. Albino mice are thus of many distinct kinds, although these kinds cannot usually be distinguished by inspection; appropriate breeding-tests, however, reveal the constitutional differences clearly.

The pied types of mice are less definite than those of rabbits and rats, but their coat-pattern is also known to follow Mendel's law in inheritance. Pied mice frequently behave as recessives to whole or self-coloured animals, and Cuénot was led to conclude that the pied forms with more white are recessive to those with less. Miss Durham, however, found that certain pied mice behaved as dominants when crossed with self-coloured mice, being in this respect analogous to the "English patterned" rabbits. This occurrence of both dominant and recessive piedness in tame House Mice affords an interesting parallel to the similar occurrence of dominant and recessive yellow mice discussed above.

Although further remarks upon coloration and coat-pattern, from a more general point of view, must be reserved for the introduction to this work, it is necessary to state here that Mendelian factors are by no means simple things as a rule. Each factor is perhaps to be regarded as the physiological expression of the sum of a multitude of characters assembled in a definite combination. When one or more of these characters drop out of, or others enter the complex, the latter is disturbed, and by readjustment a new combination, more or less different from its parent, is formed; this new combination betrays itself by producing a more or less well-marked modification of colour or pattern; and thus we become aware of the fact that "factor *X*" or "colour determiner *Y*" are mosaics, and not units.[1]

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[1] Reference may be made to the following literature for details and further references:—Bateson, *Proc. Zool. Soc.*, 1903, ii., 71; Mendel's *Principles of Heredity*, Cambridge, 1909; Cuénot, *Arch. Zool. Expér. et Gén. Notes et Rev.*, 1902, xxvii.; 1903, xxxiii.; 1904, xlv.; 1905, cxxiii.; 1907, i.; *Bull. Mens. Réunion Biol. Nancy*, 1904, 1050; and *Brünn Verh. Naturfor. Ver.*, 49, 214; Castle and Little, *Science*, N.S., 32, 868, 1910; Darbishire, *Biometrika*, ii., 1902, 101, 165, and

Geographical variation:—Of the seven European forms of *Mus* recognised by Miller, two only are referred by him to *M. musculus*, viz.: *M. m. musculus*, described above, and *M. m. azoricus*, Schinz, inhabiting the Azores and the Mediterranean region. The latter sub-species is distinguished from the typical form by its lighter and yellower back, and its buffy grey, instead of dusky grey belly. It may be regarded merely as a phase of coloration appropriate to a sunnier climate, and the gap between it and the dusky indoor animal of northern countries is, at least, partly bridged by our more pallid outdoor individuals. Winge (*op. cit.*, 89) states that at present the wild-coloured race is the common one in Denmark; he adds that formerly the dusky indoor form has certainly been preponderant. Two insular forms, *M. muralis* and *M. færoensis*, from St Kilda and the Færoes respectively, are accorded full specific rank by Miller; these are discussed below.

The remaining three European members of the genus are treated by Miller as sub-species of *M. spicilegus*, Petényi, described from Hungary. This species differs from *M. musculus* in its smaller size (condylo-basal length of skull rarely attaining 21; hind foot usually between 15 and 17 mm.); in having the tail nearly always noticeably shorter than the head and body, the under parts whitish and sharply contrasted with the flanks, and the notch of the upper incisor less developed. The typical form, characterised by its clear greyish-brown upper parts, ranges from the northern part of the Balkan Peninsula to the Baltic, and westwards into southern Sweden. Its representative in central and southern Spain is *M. s. hispanicus*, Miller, in which the dorsal colour is "buffy, or pale buffy grey." The third sub-species is *M. s. lusitanicus*, Miller, known only from Cintra, Portugal; in this the upper parts are brownish-grey, and show a decided tinge of russet. Both Thomas (*Zoologist*, 1896, 137), who first discovered *M. spicilegus* in Portugal and afterwards in the Balearic Islands, and Miller (*Catalogue*, 877) regard this species as truly indigenous to the Mediterranean region. It leads a perfectly wild life in fields, scrub, and open, dry forest, and it thus affords in station and coloration a close parallel to *Epimys rattus frugivorus*. It appears to be the natural representative in Europe of *M. spretus*, Lataste,[1] from North Africa; and Thomas states that "like the Mungoose and the Genet, it forms part

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282, iii., 1 (Japanese Waltzing Mice crossed with European albinos); Durham, *Rep. Evol. Comm. Roy. Soc.*, iv., 41, 1908; Hagedoorn, *Univ. California Pub. Physiol.*, iii., 1909, 95; *Zeitsch. indukt. Abstammungslehre*, Berlin, 6, 1912, 97; and Little, *Washington Carnegie Inst.*, *Pub.* No. 179, 1913, 11.

[1] *Actes Soc. Linn.*, Bordeaux, 1883, 17; but later (*Cat. crit. Mamm. Tunis*, Paris, 1887, 22) Lataste himself recognised that *M. spretus* "is, perhaps, only a very aberrant variety of the House Mouse."

of the North African element in the Portuguese fauna." In the eastern Mediterranean region *M. gentilis*, Brants, and in southern Asia, *M. bactrianus*, Blyth, apparently represent the same group of wild, light-bellied House Mice.

It cannot be said that our knowledge of the status of the forms mentioned above is in a very satisfactory state. The characters by which these forms are distinguished from *M. musculus* are for the most part of trivial importance, and hardly sufficient to raise these mice above the rank of sub-species of *musculus*. The forms in question, however, seem to have found their way to Europe at very different times, by different routes, and in different ways; some, like *spicilegus*, have spread westwards and northwards naturally, while others, like *musculus*, have travelled as the constant companions of man. Moreover, it is just possible, as noticed above, that the genus was present here during part of the Pleistocene; and if this be so, either *M. muralis*, *færoensis*, or *spicilegus*, or all three, may be the descendants of this ancient stock. For the present, therefore, pending further research upon the very difficult problems involved, it would seem better to follow the somewhat delicate classification adopted by Miller, than to group all these forms as mere sub-species of *musculus*.

A systematic study of the American colonies of *Mus* and *Epimys* might yield important information concerning the mechanics of geographical variation. The absence of native *Murinæ* from the New World eliminates one of the chief difficulties attending such research in the Old World; for, in the latter, we cannot ascertain to what extent newcomers have blended with indigenous species of these genera in any given region. J. A. Allen (*Bull. Am. Mus. Nat. Hist.*, 1894, 175; 1895, 236; 1896, 59; 1897, 35, 116, 198 (Allen and Chapman); 1899, 8; 1903, 540; 1904, 435; and 1910, 101) has given detailed descriptions of many American specimens of *Mus*. House Mice from Cajabamba, Peru, showed a strong tinge of rusty buff, and similarly coloured examples are before us from Ecuador and Cordoba, Argentina; those from Santa Marta, Colombia, were also rather more fulvous above and below than are normal specimens from the United States; those from San José, Costa Rica, were unusually pallid. In Texas and Arizona the species lives, in many places, a quite wild life, and is developing a remarkably red coloration. House Mice were found at Jalapa, Vera Cruz, inhabiting "old fields" in company with native rodents; these mice have been recognised by Allen and Chapman as forming a distinct sub-species, their *M. musculus jalapæ*, characterised by having the mid-dorsal region and tail of a uniform deep black throughout, the sides yellowish-grey, or ordinary mouse colour, the belly pale buffy grey, and the feet and ears dark brown. Similarly, dark coloured mice, perhaps belonging to the same sub-species, occur in Nicaragua. Winge

(*E. Museo Lundii*, iii., 60; and *Danmarks Pattedyr*, 90) has drawn attention to the fact that in the relatively small House Mice from Lagoa Santa, Brazil, $m\frac{3}{3}$ are in course of reduction, being sometimes wholly lacking, sometimes wanting from one or the other jaw, and when present always smaller than in European examples. In a skull from Cordoba these teeth are absent from both sides of the upper jaw, while they are greatly reduced in the mandible. There is thus ample evidence of the fact that *M. musculus* is capable of developing new forms adapted for leading a wild life amid foreign surroundings and among strange competitors.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
SPECIMENS FROM REIGATE, SURREY, CAUGHT AND MEASURED BY L. E. ADAMS.					
SEXUALLY IMMATURE OF BOTH SEXES:—					
1. 19th Feb. 1912, average of 7; furred above, eyes and ears closed . . .	44	35	13	5·5	3·5
2. 19th Feb. 1912, average of 4; furred above, eyes and ears closed . . .	45	33	13·5	6	4
3. 19th Feb. 1912, male; furred above and slightly below, eyes and ears closed .	53	41	14	6	5
4. 19th Feb. 1912, female; fully furred, eyes and ears open	55	64	18	12	7
5. 28th Aug. 1913, male; full first pelage .	58	62	17	11	8
6. 17th Dec. 1912, male	59	59	16	11	7
7. 30th Dec. 1912, female	59	60	16	11	10
8. 29th April 1913, male; adult pelage above, almost adult below . . .	60	58	17	12	8·5[1]
9. 19th Feb. 1912, female; adult pelage above, almost adult below . . .	64	74	17	13	11[1]
10. 29th Aug. 1913, male; complete adult pelage	64	68	17	12	9
11. 2nd May 1913, male; nearly full pelage	65	62	17	12	8·5
12. 29th Aug. 1913, male; complete adult pelage	65	65	17	11	9
13. 8th Aug. 1913, male; first pelage below	67	65	16	12·5	10
14. 9th Aug. 1913, male; complete adult pelage	67	67	16	12	10
15. 11th Oct. 1911, female; complete adult pelage	68	64	19	13	8
16. 8th Aug. 1913, male; complete adult pelage	68	69	16·5	11·5	12
17. 31st Aug. 1913, female; not quite adult pelage below	69	64	17	12	9
18. 13th July 1913, female; complete adult pelage	69	72	16	12	11
19. Jan. 1912, male; complete adult pelage.	69	77	17	13	10
20. 15th Feb. 1913, female; complete adult pelage	70	67	15·5	11	13
21. 29th Aug. 1913, female; adult pelage, but imperforate	70	75	16	12	12
22. 1st May 1913, female; adult pelage, but imperforate	83	78	16	12	15

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[1] Nos. 8 and 9 are respectively the minimum and maximum of a series of seven recorded in Adams's original table.

SPECIMENS FROM REIGATE, SURREY—(*continued*).

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.		Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes
SEXUALLY MATURE MALES:—						SEXUALLY MATURE FEMALES:—					
1. 11th Oct. 1911	81	83	22	16	15	1. Oct. 1911	70	70	21	13	10
2. ,, ,, ,,	79	78	17	13	15	2. ,, ,, ,,	75	78	21	15	12[1]
3. ,, ,, ,,	83	76	17	13	16	3. ,, ,, ,,	83	77	17	13	17
4. 12th Jan. 1912	84	80	17	11	17	4. 11th Dec. ,,	83	83	17	13	18
5. ,, ,, ,,	79	80	18	12	15	5. ,, ,, ,,	73	75	16	12	12
6. ,, ,, ,,	75	75	17	12·5	13	6. ,, ,, ,,	74	74	17	13	14
7. ,, ,, ,,	74	73	17·5	11	15	7. Feb. 1912	90	84	18	13	30[2]
8. ,, ,, ,,	79	78	18	12	14	8. ,, ,, ,,	73	73	18	13	14
9. ,, ,, ,,	80	79	17	12	15	9. ,, ,, ,,	83	80	17	13	24[3]
10. ,, ,, ,,	81	77	17	13	14	10. ,, ,, ,,	75	82	18	11	15[4]
11. 20th ,, ,,	75	70	17	13	14	11. ,, ,, ,,	76	72	17	13	19[5]
12. 13th Feb. ,,	81	75	17	14	15	12. ,, ,, ,,	77	82	18	14	19[6]
13. 19th ,, ,,	72	76	18·5	12	16	13. ,, ,, ,,	80	83	17	18	21[7]
14. ,, ,, ,,	82	77	17	12	16	14. ,, ,, ,,	75	76	18	12	18[8]
15. ,, ,, ,,	83	81	19	14	21	15. ,, ,, ,,	71	73	18	11	16[9]
16. ,, ,, ,,	75	78	18	13	17	16. ,, ,, ,,	70	79	13	11	16
17. ,, ,, ,,	75	81	18	13	20	17. ,, ,, ,,	77	79	17	14	14[10]
18. 27th ,, ,,	76	78	18	12	13	18. ,, ,, ,,	78	72	18	12	13
19 28th May ,,	80	73	17	11·5	14	19. ,, ,, ,,	78	76	17	13	13
20. ,, ,, ,,	76	74	17	11	14	20. ,, ,, ,,	92	82	18	13	19
Average . .	79	77·6	17·7	12·5	15·6	Average . .	77·6	77·5	17·8	13·1	16·5

[1] From Bishop's Stortford. [2] With 7 large embryos. [3] Suckling; no embryos. [4] With 8 embryos. [5] With 5 embryos. [6] With 8 embryos. [7] With 6 embryos. [8] With 7 embryos. [9] With 7 embryos. [10] With 8 embryos.

FERAL SPECIMENS FROM NEAR INVERGORDON, EAST ROSS-SHIRE, CAUGHT AND MEASURED BY EWEN KENNEDY.

	Head and body.	Tail (without terminal hairs).	Hind foot (without claws).	Ear (greatest length).	Weight in grammes.
1. 12th May 1905	82	85	19	13	18·5
2. 15th ,, (male) . .	70	79	19	12	19·2
3. 15th May 1912	51	71	19	14	12·5
4. ,, ,, (male) . . .	74	72	16	14	18·1

Remarks:—The largest specimen measured by Adams was a male taken at Clifton, Derbyshire, in January 1895; this had the head and body 95, and the tail 87 mm. long; its weight was 23 grammes. Adams found the average length of the head and body to be 78·6 in thirty-four males; 78·1 in twenty-eight females; and nearly 78·4 in the total of sixty-two of both sexes.

Skull:—In adults; condylo-basal length, 19·7 to 22; zygomatic breadth, 10·6 to 12·4; interorbital constriction, 3·5 to 4; breadth of brain-case, 9·8 to 10·4; median depth of brain-case, 6 to 7; length of nasal, 7·4 to 8·8; of diastema, 5 to 6·2; of mandible, 11·4 to 13; of maxillary tooth-row (alveolar), 3·4 to 3·6; of mandibular tooth-row, 3 to 3·2.

Distinguishing characters:—Specimens in the tawny outdoor pelage can readily be mistaken for young Field Mice, especially when both species are caught together. The short, broad foot, the characters of the palmar and plantar tubercles, the small eyes, the presence of ten mammæ in the female, and the peculiar odour, afford the surest means of identification; while the characters of the skull and teeth are, of course, absolutely diagnostic.

It is hardly necessary to describe the habits of such a familiar, elegant, and entertaining little thief as the House Mouse. Of very delicate build, its movements are rapid: running with great speed for short distances, it occasionally bounds and can make leaps from astonishing heights without sustaining injury. It is a good climber, and can swim well, although perhaps it does not take to water in normal circumstances. Though possibly possessing only indifferent sight, it is gifted with acute senses of smell and hearing, and is very quick to perceive and escape danger.

With the possible former exception of the Black Rat, no other mammal has been able to effect so strong, though uninvited, an alliance with man as the House Mouse. Few articles of human food come amiss to it, and few houses in Britain resist its invasion or refuse it shelter. It makes its home in all sorts of recesses, behind skirtings, beneath flooring and hearths, in cupboards, bookcases, church organs, pianofortes, and other heavy articles of furniture. It is mainly nocturnal in its habits, visiting hearths, tables, and larders in search of food; yet it not infrequently steals out of its hiding-place during quiet moments of the day. When present in small numbers mice do little harm, and their graceful movements by the fireside often compensate us for such damage as they cause. When the colony is a large one, however, they occasion much loss and annoyance; gnawing their way through woodwork and plaster, they sometimes cause considerable damage to property and fixtures; in the library they nibble away the margins of books, but, not finding ink palatable, they usually refrain from the text; articles of clothing and leather goods of all kinds may be attacked; holes are bitten in tablecloths and napkins where spotted by grease; and in the larder they attack every available food, destroying far more than they eat by tainting it with their droppings and unsavoury odour. By climbing curtains and blinds they reach suspended bird-cages, stealing the seeds, and not infrequently injuring or killing the birds. In stores, warehouses, barns, granaries, and cornstacks they are, of course, an unmitigated nuisance, and the cause of great pecuniary loss. Immune from attack and multiplying in hosts, they drill the whole interior of a cornstack, forming a labyrinth of runs, and occasionally—with the assistance of Harvest and Field Mice—make incalculable havoc amongst the grain. At threshing, notwithstanding the fact that vast numbers succeed in escaping, hundreds may be killed in a single rick.[1]

Like rats, the House Mouse shows a propensity for following a definite track to and from its hole; advantage may be taken of this habit in trapping mice. It is often said to be suspicious of traps, especially those smelling of previous occupants; Adams (*MS.*) says this is difficult to prove or disprove, but he is inclined to disbelieve it, and thinks that when House Mice refuse to enter traps, it is either because they do not perceive the bait, or else because there is other food more to their taste near at hand. They will sometimes jump over traps placed in their path. Once when much troubled with mice, we set a trap between a fender and chimneypiece, through which aperture we had seen a mouse running on several occasions from the fireplace. We sat quietly watching the trap; in due course the mouse came out and leapt safely over the trap; we gently tapped the floor with a foot, and the mouse turned and jumped back again. A few minutes later the mouse and we repeated this performance. Finally the mouse made a third exit over the trap; we stamped the floor loudly, and (rather sorrowfully) saw the frightened little beast jump on to the trap in trying to return to its home. If alarmed in a room, a mouse will usually try to reach its hole by running round close to the wall, or along the top of the skirting, seldom taking a direct course across the floor.

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[1] This species frequently plays a great part in the development of a mouse plague. Perhaps the most serious instance has been afforded recently by the great mouse plague in South Australia and Victoria, in which the House Mouse was the chief species involved. The plague developed in the bush as well as in the wheatland in 1916 and 1917, after two abnormally heavy harvests. The wheat had been sold to the British Government, and it lay stacked in bags ready for shipment. Ships were lacking; and the stacks remained unprotected from a possible attack by the rodents. As cold weather approached, the mice invaded the stacks and quickly produced ruin and disease. The damage done to wheat is estimated to be well over £1,000,000, and much damage was done also to other property. Myriads of mice were present; thus 70,000, weighing about one ton, were killed in an afternoon in one wheatyard alone (Hinton, *Rats and Mice as Enemies of Mankind*, Economic Series, No. 8, British Museum, 1918, p. 41).

Though usually extremely timid, the House Mouse sometimes, when not molested, will show a certain amount of impudent boldness. We know of one case where a mouse entered a paper bag containing biscuits, and began to nibble them, with much rustling, within a few inches of a man lying in bed reading.[1] We knew an actor who used to eat a lonely and frugal supper long after midnight. One night a mouse climbed on to the cloth at the other end of the table, and finding our friend both harmless and hospitable, it became a regular visitor. Nor is such audacity exhibited before man alone, for Mr Beavan mentions mice running between the legs of the Golden Eagles and scampering over the Tiger at the Zoo.

The eyes of the House Mice are described by Prof. C. V. Boys (*Nature*, 1st February 1912, 447) as being "autophanous"[2]—shining pale ruby or rather spinel—and they do not mind being illuminated, if there is no conspicuous movement. This writer also found them not to mind loud noises or singing, provided "s," "k," "or other sudden sounds" were not used.

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[1] Mr Cocks (*in lit.*) says:—"One night, soon after I had fallen asleep, I was awakened by a mouse sitting on my pillow, nibbling my hair (I use no lubricant). I stealthily put my arm up and made a grab, but not being able to see it, besides, perhaps, being hardly fully awake, I missed the mouse, which jumped off the bed and ran away. I soon fell asleep again, but before long was again awakened by the mouse eating my hair; the process as just described was repeated not only that once but two or three more times, at intervals of perhaps half an hour or rather longer. At last I made rather a better shot and touched the mouse, though again failing to secure it, and it finally disappeared. The mouse no doubt was ravenously hungry."

[2] The term "autophanous" was introduced by Col. J. Herschel (*Nature*, 18th Jan. 1912, 377) to describe eyes which (like those of cats and dogs) appear to emit light, by shining when seen in the dark. Such eyes are, of course, not autophanous at all (as Herschel points out); they merely reflect light which is seen when the eye of the observer is nearly in line with the illuminating source; and they act exactly as do the "reflex lights" used by cyclists. When the retina is backed by black pigment, as in normal men and monkeys, the eye is not autophanous, but forms the best possible means for obtaining sharp and clear vision. When the pigment is lacking, the retina rests directly upon a burnished surface—the tapetum; the eye is then autophanous; and while clearness of vision is impaired, the greatest possible power of detecting motion, in objects under observation, is conferred.

The little, shrill squeaks, uttered in rapid succession when pairing, fighting, or alarmed, constituting the normal voice of the House Mouse, are familiar to all. Mice are supposed by some to be fond of music, and the remarkable songs of "singing mice," resembling as they do occasionally the trills of canaries and other song-birds, have caused others, as Bordier, to claim that mice are sometimes capable of learning to imitate singing birds, and even of teaching this art to subsequent pupils, situated in less favourable circumstances. Brehm, a sceptic himself, mentions that a traveller records that the inhabitants of Central China keep mice instead of canaries in their cages, and that the songs of such "birds" fill Europeans with astonishment.

"Singing mice" have been heard by many in Britain, France, and Germany, and they have given rise to much literature and controversy. These mice make their appearance in houses, where previously the mice have possessed merely normal voices; in some cases only one individual sings, but in others a nest or the entire colony have the power of song. Sometimes the song is heard only towards dusk, or in the night; sometimes it is heard both by day and night; it may be continuous, or it may last for longer or shorter periods, alternating with more or less prolonged intervals of rest. In one case where the mouse sang both in the daytime and by night, a song lasted for ten minutes at the most during the day, but for fifteen minutes or more at night. The song itself is variously described, but appears to have little in common with the ordinary voice of a mouse. At its worst (in a male albino), it is a chirping, a medley of sounds, affording not the slightest resemblance to the clear notes of a canary or the deep trills of a thrush, but audible in the quiet of night at a distance of twenty paces (Schacht); or something between the sound of a wren and shrew, rather pleasing than otherwise (Slater). In other cases the listener has heard in it sweet thrilling notes, uttered very rapidly like the trills of a very voluble canary, sometimes loud and piercing, and sometimes dying away into the softest of cadences. Mr Coward (*in lit.*) describes one which he heard in June 1912 as sounding like a weak-voiced canary; its notes were sung with great rapidity, almost in a trill, and its compass was thought to embrace half a dozen notes or more, of which the higher ones were decidedly sweet. Mr Sidebotham described one which he heard in an hotel at Mentone in 1877,[1] whose song was not unlike that of canaries in many of its trills, but had more variety, some of its lower notes being much more like those of the bullfinch. Moreover it had a sort of double song, an air consisting of loud and full, though low, notes, and a quite subdued accompaniment; so striking was this that some, when hearing the mouse for the first time, attributed the song to two singers. A young mouse of normal appearance kept by Prof. Liebe appears to have been the most accomplished vocalist hitherto described; its voice ranged through two octaves, the notes partly resembling the high tones of the lark, partly the long-drawn, flute-like tones of the nightingale, and partly the deep, liquid trilling of the canary, and it distinguished itself by its beautiful cadences. Although occasionally pleasing or even beautiful, the melody emitted by mice is said to lack any definite or strophic character. The mice have no sense of time, and Mr English says that the effect of a number of them singing in chorus, but out of time, is ludicrous.

A "singing mouse" may give vent to its song in all sorts of positions and when engaged in all sorts of actions, as when sitting, cleaning itself, climbing or descending, running or eating. In some cases the throat has been observed to vibrate during the song, and the snout has been held in the air, and extended like that of a dog when howling. Mr Romanes found the song to be evoked by two opposite conditions—when undisturbed, his mice were quiet during the day and began to sing at night, but when alarmed, by handling or otherwise, whether during the day or night, they were sure to sing vigorously; these two songs of contentment or fear respectively differed somewhat in character. Others have noted more vigorous singing by the mice after changes in the weather, or when feeding or cleaning themselves, or when in the presence of a numerous human company.

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[1] Mr Coward tells us that his father heard a singing mouse in a room of an hotel at Mentone about 1877; possibly this was the individual described by Mr Sidebotham.

Some observers are disposed to regard the song as a sexual call peculiar to some males; it so happens that, if we reject as unreliable Mr English's determination of the female sex of a large singing mouse which he saw running away, the few cases where the sex has been definitely recorded are all males; but really there is no evidence of such a restriction, and it is difficult to imagine that the occasionally large colonies of such mice do not include individuals of both sexes. Jackel (in Landois, 1882) thought that the song proceeded from a nest of young mice and their parents, clamorous with joy at reunion; some have attributed the song to contentment, pleasure, or fear; while others, though aware that possibly a diseased condition of the respiratory organs affords the most likely explanation, have been quite unable to detect any trace of disease or weakness in the quality of the sounds. Mr English thought that the performances of the colony studied by him were of a competitive kind, and he attributed the singing to hysteria. Liebe thought that the vocal powers of his mouse were due to the presence of a membrane in the windpipe which served to straiten the aperture. Dr Cohen examined a number of singing mice and found traces of inflammation in the windpipes of all; he attributed the song to the unhealthy and straitened condition of this organ, and regarded the quick mortality, found by himself and others among these mice, as further evidence of such unhealthiness. Landois also carefully examined a half-grown singing mouse. While Cohen heard the song only during inspiration, Landois's specimen emitted sounds continuously during both inspiration and expiration—the tone was louder and clearer during expiration, weaker during inspiration; there were four breaths, and therefore eight distinct and quite involuntary sounds per second; the sounds were shrill and light, but quite audible across a large room; when heard from a distance they were more sonorous, because the higher tones of expiration blended with each other and were less interrupted; the rhythm was clearly due to respiration. Experiment and subsequent autopsy showed the song of this mouse to be due to an inflamed condition of the narial passages. Mr Slater, however, points out that his mouse was not short-lived, and that it begat a numerous progeny; while Herr Struck mentions that a singing mouse lived seven months, and another for more than nine months in captivity.

"Singing mice" of other species are known also; Landois mentions such among Field Mice,[1] Grass Mice, and Shrews. The Rev. S. F. Lockwood described a musical *Hesperomys* which had two chief songs, these being given in the description in musical notation; this case has been noticed by Darwin in *The Descent of Man.*

Reviewing all the facts relating to "singing mice" with which we are acquainted, we are inclined to think that in all cases the song is produced by a derangement of one or other of the respiratory organs. We are aware of no case in which a "singing mouse" has been proved to be healthy in this respect, and the few cases in which post-mortem examinations have been made have always revealed traces of inflammation. Sometimes the disorder is purely of an individual kind, but at others it appears to be contagious, and to affect young and old alike. In some cases the disease terminates in early death; while in others it seems to be a milder but chronic disorder, which apparently does not greatly diminish the vitality of the mouse or its power of reproducing its kind. That mice are capable of imitating song-birds, we disbelieve: many singing mice are recorded from houses where there have been no birds; and as Lataste points out, the shops of those dealers who store tame mice and song-birds together in large numbers, would have long ere this provided clear proof of such a remarkable faculty if such in fact existed.[2]

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[1] See also p. 514 above.

[2] The following is the list of literature consulted in preparing the above account of "singing mice":—E. Newman, *Zoologist*, 1843, 288; J. Collins, *ibid.*, 1849, 2474; J. Farr, *ibid.*, 1857, 5591; H. Fry and E. Newman, *ibid.*, 1865, 9432; Bampfield in Wood, *Illustrated Nat. Hist.*, 1860, 558; Brehm, *Thierleben*, ii., 132; Hugo, *Proc. Verb. Soc. Zool. France*, ii., 1877, 87; Bordier, *La Nature*, 1876, 415, and 1877, 133; Brierre, *Fr. Soc. d'Acclim.*, 1877, and *Nature*, xvi., 1877, 558; H. H. Slater,

The Japanese have cultivated a breed of tame House Mice remarkable for their habit of running round and round in circles when in the open, whence they are called "dancing or waltzing mice." In 1894 William Blasius showed specimens to Barrett-Hamilton, and informed him that two or three will join to make one composite circle, and thus have a tendency to damage each other's tails; in apparent proof of which, Barrett-Hamilton noticed that the old mice had no tails, whereas a young one was well provided. These mice appeared to be tame white mice marked with black. Waltzing mice of various colours are known; in some the eyes are black, in others pink; the pink-eyed types breed true to that character. When exposed to light, such mice run round after their tails, spinning with great rapidity. Very often, if not invariably, the waltzing habit is correlated with a malformation of the internal ear, and "waltzers" are always of delicate constitution; but the physiological cause of the habit is not well understood at present. From the experiments made by Von Guaita and Darbishire it would appear that "waltzers" behave as complete recessives when crossed with normal non-waltzing types.[1]

It is of interest to note that "waltzing black rats" appeared in the course of Bonhote's breeding experiments, with the progeny of a cross between *E. r. alexandrinus* and *E. r. frugivorus* (*Proc. Zool. Soc.*, 1912, 6). These also proved to be very delicate.

The nest of the House Mouse is composed of soft materials such as straw, hay, woollen and cotton rags, or paper; these

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Nature, xvii., 1877, 11; J. Sidebotham, *ibid.*, 29; G. J. Romanes, *ibid.*, 29; Landois, *Zool. Gart.*, 1871, 162, and *Jahresb. Westfal. Verein.*, xi., 1882-3, 17 and 21; Struck, *Arch. Ver. Mecklenburg*, xxxv., 117; Lataste, *Zooethique*, 1887, 287; Lockwood, *Amer. Nat.*, 1871, v., 761; Darwin, *Descent of Man*, 568, 865; A. H. Cocks, *Bucks;* Douglas English, *Some Smaller British Mammals*, 84; Coburn, *Journ. An. Behaviour*, ii., 1912, 364, and iii., 1913, 388; and T. Coward, *in lit.*, to Barrett-Hamilton, 2nd July 1912. Numerous other references will be found in some of the papers cited—notably in those of Landois and Struck.

[1] See Von Guaita, *Ber. Naturf. Ges. Freiburg.*, x., 1898, 317, and xi., 1900, 131; Darbishire, *Biometrika*, ii., 1902, 101, 165, 282, and iii., 1903, 1; Durham, *Rep. Evol. Comm. Roy. Soc.*, iv., 1908, 41; Bateson, *Mendel's Principles of Heredity*, 1909, 33 and 111; Alexander and Kreidi, *Monatschr. Ohrenheilk.*, Berlin, 35, 1901, 78; Yerkes, *The Dancing Mouse*, New York, 1907; Quix, *Amsterdam, Werk. Gen. Nat. Genees. Heelk.*, 1909, 83.

materials are usually first bitten into shreds. In comfortable surroundings and in the presence of abundant food, young are born in every month of the year, and one dam may have many successive litters in each year. Sometimes the young are dropped gregariously, several litters of different ages together, so that as many as fifty young mice have been found in a single nest.[1] The number of young per litter is variable, but seems to average between five and six; ten pregnant females examined by Cocks between the months of January and May of different years, contained nine, seven (twice), six (four times), five, four, and two fœtuses—giving an average of nearly six per litter. Barrett-Hamilton observed ten in a family born at Kilmanock in September 1910, and copulation took place immediately after parturition. Lataste (290) observed, in his tame specimens, a short period of rut, never longer than half a day, immediately following parturition; he found the period of gestation to vary between nineteen and twenty-one days normally,[2] or to last thirty-one days where lactation caused delay in development of the embryos. Others have observed much shorter gestation; thus Bonhote[3] gives it as about thirteen days, and Temple[4] recording that a Desert Mouse (*Gerbillus*) gave birth to one on 24th August and to four young on the following 5th September, also mentions that a similar period of twelve days was once observed in common fancy mice. Bonhote (*in lit.*) says that he does not doubt the correctness of Lataste's notes, but since he knows that a large variation in the period of gestation exists in *Meriones*, he expects that a similar variation may exist in the House Mouse.

The young are born blind, naked, and pink; but, according to Macgillivray, they grow so rapidly that in a fortnight they are able to shift for themselves. Lataste (304) found, subject of course to individual variation, young domesticated House

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[1] *Field*, 8th February 1913, 283 ("Dabchick" and "Ed.").

[2] Quite a good though brief account of this species was given by Oken (*Allgem. Naturgesch.*, Bd. 7, Abt. 2, 716, 1838); he states the period of gestation as three weeks, the number of young as four to six, while ten might be nourished; and that the young can take care of themselves in fourteen days.

[3] J. L. Bonhote, *Proc. Zool. Soc.*, 1911, 5.

[4] W. R. Temple, *Field*, 13th September 1913, 620.

Mice at the sixth day commenced to be clothed, at the thirteenth day they were completely clothed, and had the external auditory meatus open; at the fourteenth to the fifteenth day the eyes opened; on the nineteenth day (but sometimes as early as the sixteenth) they were able to leave the mother, although they would suckle for a few days more if opportunity permitted; at this age their parents do not molest them, but soon after they will massacre the young. The male will copulate when 1½ months old, and a female 116 days old bore young after copulation with a male of her own age. Lataste observed them to be very voiceful, crying at birth. Saint-Loup[1] finds the rate of growth to be most rapid immediately after birth; it then decreases continually during eighteen days; from the nineteenth to the twenty-second day it rises again, but without attaining a quarter of the initial rate; afterwards it fluctuates.

Despite their disagreeable odour, which impregnates their cages and everything they touch, many find tame House Mice attractive pets; there is a National Mouse Club, and "shows" are held at which prizes are awarded to the best representatives of the very numerous recognised classes or breeds. These mice have long been tamed, and certain of the coloured races are of respectable antiquity; thus Merrett (*Pinax*, 167, 1667) was acquainted with white, ashy and dark varieties, and it is worth noting that he does not speak of coloured rats. Brehm (*Thierleben*, ii., 134) states that tame mice are fond of spirits, but Lataste found that pure rum had no attraction for those kept by him. The latter writer describes his captives as being essentially, though not absolutely, nocturnal; with well-developed senses, and intelligent, though not so well endowed in these respects as the Brown Rat; they are excellent climbers, with feebly, but really, prehensile tails, which are especially useful to them in balancing exercises, in which they excel; they have a sense of property, and are peculiarly gentle, perhaps from long domestication, and readily handled; they are friendly to each other, unless treated foolishly or badly fed; a single cage, however, will only hold the parents and young, and the young must be removed when they become rivals of their parents. Wild House Mice are said by some to be much less easily tamed than Field Mice, but others, as Lataste, state that they are easily tamed with care; no doubt much depends upon the mouse, the circumstances, and the experimentalist. Adams (*MS.*) used to breed "white mice," and he thought them "deficient in some way (sight, hearing, like white cats with blue eyes:") he noted that when they produced a litter of normal grey ones, these were invariably more active and wild, often escaping when being handled, even when quite young. Similar experiences were recorded by Darbishire.

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[1] R. Saint-Loup, *Bull. Zool. de France*, 1893, 242.

With regard to longevity, Chalmers Mitchell (*Encycl. Brit.*, 11th ed., 16, 976*a*) says that the House Mouse may attain an age of five or six years; Oken (*op. cit.*, 716) says that "one can keep them for six years, from which it follows that they live still longer in freedom." We should not have expected such a small rodent to have attained so great an age, but we are aware of no other authoritative statements upon the subject.

2. THE ST KILDA HOUSE MOUSE.

MUS MURALIS, Barrett-Hamilton.

1899. MUS MURALIS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 81, pl. ix., fig. 2; type of female, No. 8.7.16.1 of British Museum collection, from St Kilda, Miller, *Catalogue*, 874.
1905. MUS MUSCULUS MURALIS, J. G. Millais, *Mammals of Great Britain*, ii., 198; Trouessart.
1908. MUS MUSCULUS, H. Winge, *Danmarks Pattedyr*, 88 (in part).

Distribution:—Restricted to Hirta, the only inhabited islet of the St Kilda[1] group, whence it is alone known. Here it is very abundant in the houses, but occurs also in the crofts, finding shelter in the walls and "cleits" (Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1914, 127).

History:—Steele Elliott (*Proc. Birmingham Nat. Hist. and Phil. Soc.*, 1895, 135; and *Zoologist*, 1895, 281) first obtained specimens of this mouse in May 1894; he noticed "a slight difference in its coloration from those found with us," but did not describe it further. Barrett-Hamilton (*op. cit.*, and *Ann. Scott. Nat. Hist.*, 1899, 31), working with one of Steele Elliott's specimens and others collected in 1898 by Henry Evans, published a full description and figure of the animal, and established a new species, his *M. muralis*, for its reception. He thought that this mouse was "of at least several hundred years' standing at St Kilda," and while realising that it was very closely allied to *M. musculus*, he thought it better to regard it, pending further research upon the status of the various described members of the group, as a full species rather than as a sub-species of *musculus*. In 1906 Barrett-Hamilton (*Ann. Scott. Nat. Hist.*, 2) described a further series of specimens collected by Waterston in June 1905. In the autumns (September and October) of 1910 and 1911 Eagle Clarke made another collection, and he described these specimens in 1914 (*Ann. Scott. Nat. Hist.*, 127).

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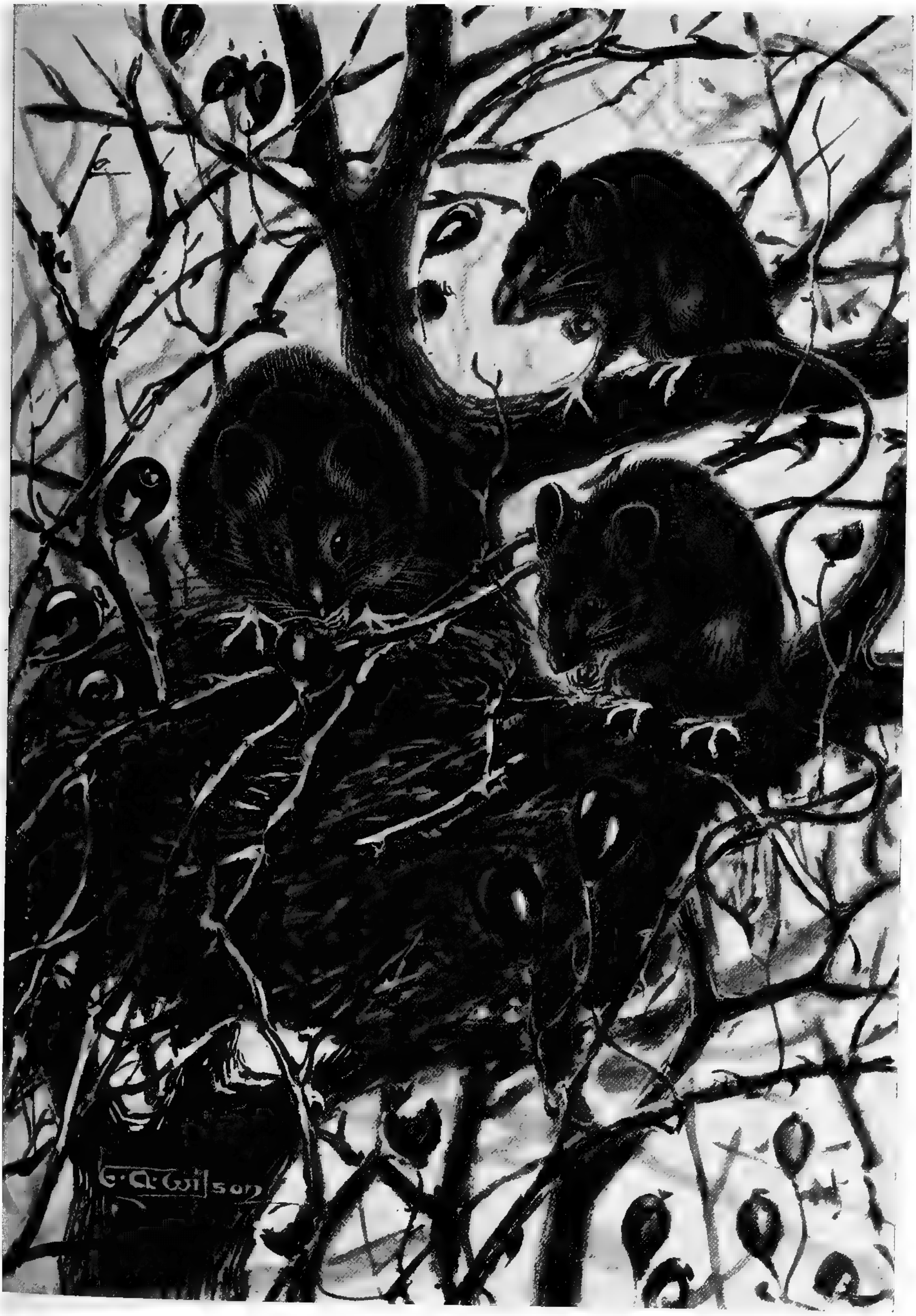
[1] As noted on p. 640 above, it is possible, however, that a representative of this species occurs on North Uist, Hebrides.

The **status** of *M. muralis* has been discussed by various writers. Lydekker (*Field*, 30th April 1904) and Winge (1908) regard it as no more than a local race, while Millais and Trouessart treat it as a sub-species of *musculus*. Barrett-Hamilton (*Proc. Zool. Soc.*, 1899, 81) thought that since this mouse was perfectly isolated, and not known to intergrade with the parent form (*musculus*), it had "as much claim to be accorded full specific rank as any other island species." After examining all the European members of the genus, Miller came to the conclusion that *muralis* is sufficiently well differentiated to receive full specific rank. For reasons given above (p. 648), Miller's view has been adopted here, although not without hesitation.

If Miller's decision to regard the wild forms of southern and central Europe (*M. spicilegus*) and the island House Mice (*M. muralis* and *færoensis*) as distinct species be really well founded, it is possible that these species represent a more ancient stock of House Mice indigenous to western Europe. The distribution of these forms is in favour of such a theory; and the large size of the jaw from the Kirkdale Cave (see p. 636), assuming that specimen to be of Pleistocene age and really referable to this genus, figured by Owen, could be explained by referring it to a forerunner of *muralis*. Our knowledge of the matter, however, is still far from sufficient to raise any such view above the rank of a mere hypothesis.

Description:—In outward form *M. muralis* agrees closely with *musculus*, but differs in being rather larger, and in having the tail and feet more robust. The width of the hind foot, measured across the bases of the outer toes, is about 4 mm., instead of 3·5 mm., as in *musculus*.

In general **colour** the back is rather lighter than in ordinary specimens of *musculus*, the bases of the hairs are slaty, and while most of them have sepia-brown tips, a certain proportion are rufous-tipped, and give the animal a grizzled appearance. The under parts are bright



THE FIELD MOUSE.

buff or buffy white, this colour being clearly separated from that of the upper surface by a well-marked line of demarcation.

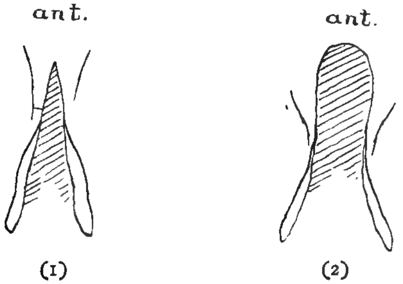


FIG. 95.—DIAGRAM OF PALATE OF *Mus muralis* (1), AND *Mus musculus* (2).

The **skull** is slightly larger than is usual in *musculus*, and the mesopterygoid fossa (Fig. 95) is greatly narrowed in front, the pterygoids converging anteriorly instead of being approximately parallel. This character, less marked in young skulls than in adults, appears to be quite constant in *muralis*, and it has not yet been observed among the large number of European skulls of *musculus* examined. The **teeth** do not differ from those of *musculus*.

DIMENSIONS IN MILLIMETRES OF *M. MURALIS* AND *FÆROENSIS*:—

	Head and body.	Tail (without terminal hairs).	Ear (greatest length).	Hind foot (without claws).
Mus muralis.				
1. 1898. Female (B.M. 8.7.16.1; type), collected by H. Evans . . .	90	85	17	14
2. Average of 6 females (from spirit), on which original descriptions were based (Barrett-Hamilton, *Ann. Scott. Nat. Hist.*, 1906, 2). . .	85·1	81·5	16·5	12·9
June 1905. Collected by J. Waterston, and described by Barrett-Hamilton, *op. cit.*—				
3. Male	87	81	17	12·5
4. Female	93	89	18	14·5
5. Do.	96	92	18	13
6. Average of 9 adults, 3 male and 6 female, collected by Waterston .	84·6	81·4	17·4	13·16
Sept.-Oct. 1910 and 1911. Collected and described by W. Eagle Clarke, *Ann. Scott. Nat. Hist.*, 1914, 127[1]				
7. Male (largest)	104·5	74	16·7	13
8. Do.	103	95·6	18·5	14
9. Do. (smallest)	94	81	17	14
10. Average of 12 males	99·3	83·4	18·5	14
11. Female (largest)	111	90·5	20	16
12. Do.	105	87	19	14
13. Do. (smallest)	94	77·5	19	14
14. Average of 17 females . . .	101·4	81·9	18·3	14·6
Mus færoensis.				
1. Male (Eagle Clarke, *Proc. Roy. Phys. Soc.*, Edinburgh, xv., 164) . . .	95·5	96·4	20·2	13·5
2. Female (type) (Eagle Clarke, *Proc. Roy. Phys. Soc.*, Edinburgh, xv., 164)	103	95	21	14
3. Male (Miller, *Catalogue*, 875) . .	85	97	20	13

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[1] Specimens with head and body 90 mm. or less excluded as immature.

Skull:—Condylo-basal length, 21 to 22·2 (at least), zygomatic breadth, 11·2 to 12·6; interorbital constriction, 3·4 to 3·8; breadth of brain-case, 9·8 to 10·2; depth of brain-case at middle, 6·8 to 7·2; length of nasal, 8 to 8·8; of diastema, 5·6 to 6·2; of maxillary tooth-row (alveolar), 3·4 to 3·8; of mandible, 12·2 to 13·8; of mandibular tooth-row (alveolar); 3 to 3·2. None of the specimens hitherto measured has had the teeth more than moderately worn, skulls with much-worn teeth are probably larger.

Mus færoensis, Clarke, remains to be noticed. This was originally described (*Proc. Roy. Phys. Soc.*, Edinburgh, xv., 1904, 163) as a subspecies of *musculus*, the type being a female, in the Edinburgh Museum, collected by Annandale and Marshall, in August 1903, on Naalsö, Færoes. In his *Catalogue* (875), Miller treats this form as a full species.

Like *M. muralis*, this mouse is remarkable for its large size, its hind feet are very robust, their width measured across the bases of the outer toes being 5 mm.; the tail is stout, its diameter near the base being about 4 mm., instead of 3·6 as in *muralis*, or about 3 as in *musculus*. In **colour** it is more like *musculus* than *muralis;* its upper surface shows "a mixture of rufous and greyish-black (the former predominating), the fur being blackish at the base, broadly margined with reddish-brown. A number of thinly distributed black hairs are also present. Under-surface a mixture of buff and pale grey, intergrading on the flanks with the tints of the upper surface. The ventral fur is pale grey at the base, broadly edged with buff" (Eagle Clarke).

Apart from its larger size (condylo-basal length, 25 to 23·4 mm.), the **skull** (Naalsö specimens) differs from that of *musculus* only in having the rostrum relatively more robust, and the brain-case perhaps a little more depressed; the mesopterygoid fossa, in the three skulls examined, is as in *musculus.*

Three specimens, in the Copenhagen Museum, from Myggenæs, another island of the group, have been described by Winge (in Clarke, *op. cit.*, 164). These also are "very stout, with exceptionally large feet, 'wild-coloured' (*i.e.* without the sooty colour common in specimens taken in large towns)," and the mesopterygoid space is contracted anteriorly, exactly as in *M. muralis.*

SCIUROMORPHA

The *Castoridæ* and *Sciuridæ*, or Beavers and Squirrels, belong to the SCIUROMORPHA—one of the three great tribes in one or other of which most of the living *Simplicidentata* can be readily arranged. Besides the two families in question, the *Sciuromorpha* comprise the American families *Heteromyidæ* (Kangaroo Rats and Pocket Mice) and *Geomyidæ* (Gophers). Winge claims the *Sciuromorpha* as descendants of an ancient rodentian stock, the *Aplodontiidæ*, of which the only living and doubtless much modified remnant is the remarkable genus *Aplodontia*, comprising the Sewellels or Mountain Beavers of the Rocky Mountain region.

The leading **character** of the *Sciuromorpha* is to be found in the **skull**, in which the infraorbital canal is always small, serving only for the passage of the infraorbital nerve and accompanying blood-vessels, and transmitting no part of the masseter muscle. In this feature the sciuromorphine skull departs widely from that of other rodents (in which the canal is large, lodging or transmitting a larger or smaller portion of the *masseter medialis* muscle), and resembles the skull of the majority of non-rodentian mammals. Nevertheless, according to Winge, the *Sciuromorpha* are descended from ancestors possessing, like other rodents, spacious infraorbital canals. In these ancestors the *masseter medialis* muscle had its normal rodentian strength and development, and part of it had its origin within the infraorbital canal; on the other hand, the deep portion of the *masseter lateralis*, arising on each side from the outer and fore part of the zygomatic arch, was not unusually large or powerful, and had not yet extended its area of origin above the level of the infraorbital foramen. In the living genus *Aplodontia* the masseter muscles still retain essentially this arrangement.

By degrees the deep portion of the *masseter lateralis* muscle became the principal means of moving the lower jaw during gnawing, and it gradually extended its area of origin upwards far above the level of the infraorbital foramen, and forwards to a greater or less extent over the surface of the ascending branch of the premaxilla. This muscle thus usurped much of the function of the *masseter medialis;* the latter therefore declined in importance and was gradually driven away from the infraorbital canal; the canal consequently was straitened, and resumed its normal mammalian status as a mere conduit for the facial nerve and vessels. Some trace of the former widened condition of the infraorbital canal can still be discerned in many living *Sciuromorpha.* Thus a little groove leading up towards the orbit from the edge of the infraorbital foramen seems to represent the closed part of the fissure—the more so since from the floor of the groove two muscles take origin, viz. the *dilator narini* and a muscle of the upper lip, which in *Muridæ* arise from the edges of the upper and outer walls of the wide canal.

CASTORIDÆ.

BEAVERS.

These are medium-sized or large rodents, formerly enjoying a wide distribution in Europe, Asia, and North America. They are known to date from the middle Oligocene of Europe and North America and from the Pliocene in Asia, but they are evidently of still more ancient origin. Represented in the Tertiary by seven or eight genera at least, the group has waned, having as its present sole survivor the genus *Castor*, or Beavers, now hastening towards extinction.

In relation to the *Sciuridæ*, the *Castoridæ* play a part resembling that of the *Microtinæ* towards the *Murinæ.* They have followed either a strictly terrestrial or an aquatic mode of living, as opposed to the freer, typically arboreal course pursued by the *Sciuridæ.* They are more primitive than the latter, in retaining a well-developed thumb, armed with a large claw; in lacking a bony roof to the orbit; and in having the cavity of the auditory bullæ undivided by osseous septa. They also do not show the marked increase in the relative size of the brain characteristic of so many *Sciuridæ*.

On the other hand they have, in many respects, attained a far higher degree of specialisation than that manifested by *Sciuridæ*. The incisor teeth are enormously developed, and the peculiar rodent function of gnawing reaches in this family its highest expression. In adapting themselves to a hard, coarse vegetable diet, their cheek-teeth have become markedly hypsodont, and display, when the tubercular caps are removed by wear, a pattern of deeply re-entrant, transverse enamel folds. Only one premolar is present in the upper jaw on each side, the dental formula being consequently $i\,\frac{1}{1}$, $p\,\frac{1}{1}$, $m\,\frac{3}{3}=20$; and the cheek-teeth are arranged in anteriorly convergent rows. The temporal, masseter, and pterygoid muscles are all powerfully developed, their strength being betrayed in the skull by heavily-built zygomatic arches, a moderately salient sagittal crest and deep pterygoid fossæ, the latter becoming, as usual, deeper and more extensive in proportion as the angular processes of the mandible diminish in size. Except in the very highly specialised extinct genus *Castoroides*, from the Pleistocene of North America, the jugal articulates with the lachrymal, and the fibula remains distinct from, though often closely connected with, the tibia, both being features shared with the *Sciuridæ*.

The British members of the family belong to two genera—*Castor*, now locally extinct, though surviving as a mere remnant in parts of Europe and Asia, as well as in North America; and *Trogontherium*, now wholly extinct, and known only from the Pliocene and Pleistocene of Europe and Asia.

GENUS CASTOR.

1758. CASTOR, Carolus Linnæus, *Syst. Nat.*, 10th ed., i., 58; type *C. fiber*, selected by tautonymy.

1806. FIBER, Dumeril, *Zoologie Analytique*, 18; a substitute for *Castor; nec Fiber* (Cuvier, 1800), which is a synonym of *Ondatra*, Link.

This genus has a circumpolar distribution, and comprises the Beavers of the Old and New Worlds. It evinces in a high degree of perfection the family specialisations for gnawing, for subsistence upon coarse vegetable foods, and for burrowing. Above all it is peculiarly modified for an aquatic existence.

Castor is first known from the Pliocene of **Europe** and from the Pleistocene of **Asia**; in **North America** it apparently dates from the Pleistocene. All the living species are very closely related. The Old World Beavers are at present referred to a single species, *C. fiber*, because, owing largely to the lack of material, all attempts to work out the geographical variation of this widely distributed animal have failed. In North America *C. canadensis* is the chief and most widely spread species; of this, six geographical races or subspecies are now recognized, while one from California (*C. subauratus*, Taylor) and another from Newfoundland (*C. cæcator*, Bangs) have been described as distinct species.[1]

THE BEAVER.

CASTOR FIBER, Linnæus.

1758. CASTOR FIBER, C. Linnæus, *Syst. Nat.*, 10th ed., i., 58; described from Sweden. Of most subsequent authors.

1792. CASTOR FIBER ALBUS and SOLITARIUS, Kerr, *Animal Kingdom*, 222 and 224.

1801. CASTOR FIBER VARIEGATUS and FULVUS, Bechstein, *Gemein. Naturgesch. Deutschlands*, ed. 2, i., 913.

1803. CASTOR GALLIÆ, Geoffroy, *Cat. Mamm. du Mus. Nat. d'Hist. Nat., Paris*, 168; described from the Rhone, France.

1822. CASTOR NIGER, VARIUS and FLAVUS, Desmarest, *Mammalogie*, part ii., 278.

1829. CASTOR FIBER GALLICUS, Fischer, *Synops. Mamm.*, 287; a substitute for *galliæ*.

1833. CASTOR PROPRIUS, Billberg, *Linn. Samf.*, 34 in footnote; a substitute for *fiber*.

1907. CASTOR ALBICUS, Matschie, *Sitz.-Ber. Gesellsch. nat. Freunde, Berlin*, 216; described from the Elbe, Germany.

1907. CASTOR VISTULINUS, Matschie, *Sitz.-Ber. Gesellsch. nat. Freunde, Berlin*, 219; described from Western Poland.

Le castor and *le bièfvre* or *bièvre* of the French: *der Biber* of the Germans.

As will be seen from the above **synonymy** numerous names, founded either upon mere individual variations of colour, or upon vain attempts to define local races without sufficient material, have been applied to the European Beaver.

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[1] Other subspecies have been described recently by W. P. Taylor in *The Status of the Beavers of Western North America*, Univ. California Publications, Zool., vol. xii., 413-495, March 20, 1916.

Terminology:—The English name of this animal has always been the "Beaver," the spelling of the word showing, as usual, considerable variation at different periods. The *New English Dictionary* mentions "*beofor*," "*befor*," "*byfor*," "*befer*," "*beuer*," "*bever*," "*bevere*," "*bevyr*," "*beauer*," and "*beavor*" as forerunners of the current form. Of these "*beofor*" and "*befor*" are the earliest, and appear in Ælfric's *Vocabulary* (*c.* 1000 A.D.) as the translation of the Latin *fiber.*

Local names:—(Non-Celtic)—"Spattletail" may have been an ancient local name for the Beaver; it is given as the translation of *Llostlydan y befyr*, "the Spattletail or Beaver," mentioned in the Anomalous Laws of Wales (*Laws and Instit. of Wales*, II., bk. xiv., 592; and Stubbs, *Lanc. Nat.*, 1910, 129). But in view of the fact that this name is apparently quite unknown to the makers of dictionaries, it seems more probable that the word was coined comparatively recently to serve as an apt translation of the Celtic *llostlydan* discussed below.

(Celtic):—Welsh—*Llostlydan* "the broad-tail": *llostlydan* or *Castor* occurs in the *Leges Wallicæ* or Laws of Howel Dda (book iii., ss. 11, 12), dating from the tenth century; *afangc* or *avanc* (discussed below under History).

Cornish:—*befer.*

Scotch Gaelic:—*Leas-leathan* (Highland Society's *Dict.*), *dobhran leas-leathan* (Shaw, *Gael. Dict.*, 1780), *leas-leathain* (Robertson).

The Welsh and Scottish Gaelic names cited above are descriptive, and there can be little or no doubt that they were applied to the Beaver. *Llost* or *leas*, with the Old Irish *loss*, signifies "tail," and *llydan* or *leathan* = "broad," hence *llostlydan* means "broad-tail." *Dobhran-chu* signifies "water-dog," or Otter, and therefore the combination *dobhran leas-leathan* = the "broad-tailed Otter," or Beaver.

The similarity of the Welsh and Scotch names is of course striking, but a good deal of doubt exists as to the status of *leas-leathan* in the Highland tongue. The Gaels could have had no personal knowledge of the Beaver in Ireland, and it is suggested by Robertson that on their arrival in Scotland they "borrowed a name from the native Pictish inhabitants." For a full discussion of this matter the reader may be referred to C. H. Alston's *Wild Life in the West Highlands*, 34. From what is stated below with regard to the etymology of the word "beaver," it is probable that the original and general Celtic name for the animal was not a descriptive term, like *llostlydan*, but a variant of the Old Aryan *bebhrus*; and thus one can account for the use of *befyr* in the Anomalous Laws of Wales, and for the presence of *befer* in Cornish without supposing that these words crept into Celtic vocabularies by contact with Anglo-Saxons. "Beaver" was probably common to the languages of both races long before they met on British soil.

History and past distribution:—The range of the Beaver in the

Old World formerly covered the whole of the forested region of Eurasia, from Lapland and Northern Russia southwards to Spain, Italy, and the Euphrates, and from Great Britain eastwards at least as far as the Lena. The Asiatic limits of its distribution are, however, still imperfectly known.

The remarkable habits and powers of the Beaver, its appearance, its beautiful fur, and its possession of castoreum—that secretion which through long ages was regarded by physicians as a panacea—could not fail to attract human attention from the very earliest times. Accordingly we find the animal described or noticed in many of the most ancient writings which have survived to our day, while etymological research indicates that the name "beaver" itself dates from a time far beyond the reach of any documentary evidence in our possession. In this place only a few of the more salient facts can be mentioned, but reference may be made to the great essay on the Beaver by Brandt,[1] who dealt exhaustively with the classical references and commentaries, and for the first time collected the many scattered fruits of previous research.

The word "beaver" is in one form or another common to all the Indo-Germanic languages, and it is traceable, with its equivalents the Sanskrit *babhru*, the old Persian *baŏvara* or *baŏara*, and the nearly allied Arabic *viverra*, to the Old Aryan *bebhrus*: the latter, according to the *New English Dictionary*, is a reduplicated derivative of *bhru* = brown, with sense of "brown" or "red-brown" or "brown water animal." It does not follow, therefore, that in every instance, when using a derivative of *bebhrus*, early writers were speaking of the Beaver. Any brown fur-bearing animal would be a "beaver" to the earliest Aryans. Gradually the use of the word was limited solely to such brown fur-bearing animals as were of aquatic habits, and during this period it signified not merely the Beaver, but the Otter, Ichneumon, and Water Rat as well. This comparatively restricted meaning was acquired certainly by the time the sacred writings of the old Persian and Indian peoples were written, for in them "beavers" are clearly indicated as water-dwellers and their killing is expressly forbidden. In fact, as regards certain of the Persian documents, both Spiegel and Brandt were inclined to think that the context showed that *baŏvara* really indicated the Beaver and no other animal, and that, therefore, the word had acquired, between 300 and 400 B.C., its modern fully restricted significance.

The ancient Greek writers called the Beaver χάστωρ or *castor*, and its peculiar secretion χαστόριον. The words *castor* and *castoreum* appear to be connected with and perhaps are derived from the Indian *kasturi* or *kastora*, which signify the musk-glands and secretion of the Musk Deer, *Moschus*. These glands have a somewhat similar appearance and position in the Beaver, and their secretion has a similarly pungent odour. Therefore the name may have easily been transferred from one animal to the other in a region where one of the two species was absent. Be this as it may, there is no room for doubting that the Greeks were referring to the Beaver; and although some of them, as Aristotle, were perhaps describing it from hearsay, others, as Herodotus, Dioscorides, and Strabo had a personal knowledge of the animal. Dioscorides pointed out that the castor-sacks were quite distinct from the testes, and that the widespread belief that the Beaver, aware of the object of the chase, castrated himself before the hunter in order to obtain deliverance, was nothing but a fable. Strabo described the Beaver as inhabiting the rivers of Spain, and mentions that the Spanish castoreum had less strength than that of the Beavers of Asia Minor. This latter statement may have been well founded, since it is known that the nature of the food has no small influence upon the quality of the secretion.

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[1] J. F. Brandt, *Mem. Sc. Nat. Imp. Acad.*, *St Petersburg*, vii., 1855, 78 and 339.

The name of the Beaver among the Romans was properly *fiber*, while *Castor* was at a later date borrowed from the Greeks; thus Pliny speaks of "*fibri, quos castores vocant*"; *castor* had nothing to do with the Latin *castrare*. Varro, Festus, and more recently Harting have sought the origin of *fiber* in *fibrum*, the bank of a stream, but there seems little reason to doubt that *fiber* is a derivative of *bebhrus*, which probably came into the language by the Celtic route; the mode in which the initial *b* was transformed into *f* may be indicated by mentioning the Provençal *vibré*. Varro speaks of Beavers in the rivers of Latium, and a line in a fragmentary work of Plautus, "*Sic me subes cotidio quasi fiber salicem*," suggests that at about 200 B.C. the people of Umbria, Central Italy, had a personal acquaintance with the habits of this animal.

We are indebted to Lord Kilbracken (*per* Cocks) for referring us to Dante's *Inferno* (c. xvii., lines 19 to 25):—

> "Come tal volta stanno a riva i burchi,
> che parte sono in acqua e parte in terra;
> e come là tra li Tedeschi lurchi
> lo bevero s'assetta a far sua guerra:
> così la fiera pessima si stava
> su l'orlo che, di pietra, il sabbion serra."

"As at times the wherries lie on shore, that are part in water and part on land; and as there amongst the guzzling Germans the beaver adjusts himself to wage his war: so lay that worst of savage beasts upon the brim which closes the great sand with stone."

Dante, writing about 1310, thus uses the Beaver as an illustration familiar to his Italian readers; that he indicates a German instead of an Italian colony of these animals may be due to the fact that he could not very well employ the adjective *lurchi*, demanded by the rhyme, in connection with his own countrymen.

Beavers lived in the delta of the Po as late as the sixteenth century; a specimen was dissected in 1541 by Amatus Lusitanas at Ferrara, and *Bebriacum* is an ancient place-name (between Cremona and Verona) recalling their former occurrence.

Beavers do not appear to have ever reached **Ireland**, although in Great Britain the genus dates from the Pliocene, and *C. fiber* itself perhaps from the Pleistocene. This absence from Ireland, among other facts, led Dr Scharff to believe that Ireland was separated from Britain in early or pre-Pleistocene times. That seems a too remote period for the rupture; but it is possible that the area of the present Irish Sea was then so depressed, marshy, and devoid of woodland as to fail to tempt the Beaver to proceed westwards of Great Britain.

In **England**, jaws and teeth of species not certainly distinguishable, with such materials, from *C. fiber* have been found, in scanty numbers, in the Upper Freshwater Bed (Cromerian) of West Runton, and in several of the Pleistocene river deposits—as in those of the Thames at Ilford, Grays and Clacton in Essex. Numerous skulls and several more or less complete skeletons of *C. fiber* have been recovered from the peaty deposits, dating variously from the Neolithic, Bronze and Romano-British periods. The earliest discovery of the kind appears to have been made by Dr John Collet in 1757: he records the finding of "heads of Beavers," with the bones of other prehistoric animals, in a peat pit at Newbury, Berkshire (*Phil. Trans.*, 1757, 100). John Hunter received later part of a skull and a lower jaw from a mosspit in Berkshire: these specimens quite likely came from Newbury, whence further remains were described by Owen in 1846 (*Cat. Foss. Roy. Coll. Surg.*, 1845, 35 and 244). In 1818 Okes recorded two lower jaws from the dried bed of an old channel—"the West Water"—connecting the Nene with the Ouse near Chatteris; this ancient water-way had been choked up for more than two centuries. Since those early days many discoveries of the kind have been made in England — in Somerset, Devon, Dorset, Hampshire, Wiltshire, Berkshire, the fens of Cambridge, Suffolk, Norfolk, and Lincolnshire, in Yorkshire, and in the valleys of the Thames and its tributaries in Middlesex, Essex, and Kent. As examples clearly dating from Romano-British times may be cited the finding of Beaver remains at Glastonbury and the discovery, by Cocks, of a nearly complete mandibular ramus in the Romano-British pile-village at Hedsor, Bucks. One of the most recent "finds" was made when enlarging the Royal Albert Docks at Canning Town in 1911; a nearly complete skeleton (now in the British Museum) was there found buried in the Alluvium, beneath a prostrate tree-trunk.

The Beaver was undoubtedly a very common British mammal in the later prehistoric periods, and to its activities we may owe some very striking features of the present English landscape. Thus in East Anglia, as Dr Henry Woodward (*Trans. Essex F. C.*, 1883, iii., 8) first pointed out, the inception of the fens may have been due to the destruction of the primitive woodland by the Beaver, and the obstruction of the natural drainage formed by prostrate tree-trunks as well as by regular beaver-dams. Stubbs (*op. cit.*) similarly ascribes the destruction of the Pennine woodland and the formation of the peat-mosses of Lancashire, etc., to the work of Beavers. Similar changes are being or have been recently wrought by the same agency on a large scale in North America (Geikie, *Textbook of Geol.*, 1893, 474).

In **Scotland** also the remains of Beavers have been discovered, on several occasions, in the marly beds commonly found at the bases of the peat-mosses. The earliest find recorded is apparently that made in the deposits of the Loch of Marlee, Kinloch, Perthshire, in 1788; here a Beaver skeleton was found in a marl-pit, beneath 5 or 6 feet of peat; the skull and haunch bones were presented to the Society of Antiquaries of Scotland by Dr Farquharson (*Minute*, 16th December 1788; Neill, *Edinb. Phil. Journ.*, 1819, l., 182). Neill (*op. cit.*, 184), to whom we owe much of our knowledge of the history of the Beaver in this island, describes a skeleton found in 1818 in the course of draining Middlestot's Bog, in the parish of Edrom, Berwickshire.

As the country became settled the Beaver grew scarce and eventually disappeared. Apart from human persecution it is perhaps doubtful whether a small island like Britain could have long continued to support a large population of Beavers. There is no doubt that the animal lingered on in the historic period, and it probably did not become extinct here before the thirteenth century. In the *Leges Wallicæ* (book iii., ss. 11, 12), dating from the first half of the tenth century, skins of Martens, Otters, and Beavers (*Llostlydan*) are mentioned; and while 24 and 12 pence respectively are stated to be the values of the skins of the first two species, that of the Beaver is valued at no less a sum than 120 pence. The fur is said to have been used for the trimmings of the royal robes, and the high price set upon it shows that even at that remote date the Beaver had become extremely rare.

Gerald de Barri, better known as Giraldus Cambrensis, lived in Ireland between 1185 and 1188, and in his *Topographia Hibernica* (*Distinc.*, i., c. 21) he notes the absence of the Beaver from that country. In 1188 he travelled through Wales with Baldwin, who was then preaching the Third Crusade. In his *Itinerarium Kambriæ* (book ii., c. 3) Giraldus, as translated by Sir R. Colt Hoare, states that "the noble river Teivi," in Cardiganshire, has a productive salmon "fishery near Cilgerran, which is situated on the summit of a rock, at a place called Canarch Mawr" (now Cenarth). He adds:—"The Teivi has another singular particularity, being the only river in Wales, or even in England, which has beavers; in Scotland they are said to be found in one river, but are very scarce. I think it not a useless labour, to insert a few remarks respecting the nature of these animals; the manner in which they bring their materials from the woods to the water, and with what skill they connect them in the construction of their dwellings in the midst of rivers; their means of defence on the eastern and western sides against hunters, and also concerning their fish-like tails." After reciting the early fable as to the means by which Beavers transport timber he proceeds:—

"In some deep, still corner of the river, the beavers use such skill in the construction of their habitations, that not a drop of water can penetrate, or the force of storms shake them; nor do they fear any violence but that of mankind, nor even that, unless well armed. They entwine the branches of willows with other wood, and different kinds of leaves, to the usual height of the water, and having made within-side a communication from floor to floor, they elevate a kind of stage, or scaffold, from which they may observe and watch the rising of the waters. In the course of time, their habitations bear the appearance of a grove of willow trees, rude and natural without, but artfully constructed within. . . . It is worthy of remark, that the beaver has but four teeth, two above, and two below, which being broad and sharp, cut like a carpenter's axe, and as such he uses them. They make excavations and dry hiding-places in the banks near their dwellings, and when they hear the stroke of the hunter, who with sharp poles endeavours to penetrate them, they fly as soon as possible to the defence of their castle, having first blown out the water from the entrance of the hole, and rendered it foul and muddy by scraping the earth, in order thus artfully to elude the stratagems of the well-armed hunter, who is watching them from the opposite banks of the river." Giraldus, like other ancient writers, then relates how the Beavers ransom themselves by self-castration, and concludes his narrative with the following:—"The beavers have broad, short tails, thick like the palm of a hand, which they use as a rudder in swimming; and although the rest of their body is hairy, this part, like that of seals, is without hair and smooth; upon which account, in Germany and the Arctic regions, where beavers abound, great and religious persons, in times of fasting, eat the tails of this fish-like animal, as having both the taste and colour of fish."

In his *Description of England*, written about 1577 and prefixed to Holinshed's *Chronicles*, Harrison says:—"For to saie the truth we have not manie Bevers but onelie in the Teifie in Wales."

This statement may, of course, be only a plume borrowed from Giraldus.

The three references just dealt with constitute the whole of the reliable documentary evidence relating to the Beaver in England and Wales at present known. It is true that Price and Llwyd, in a *History of Wales* written in the reign of Henry VIII., have identified the *Castor* of Giraldus with a water beast called by the Welsh *afangc* or *avanc*, and in this they have been followed by the compilers of Welsh Dictionaries; our authors added that only the name of the beast lingered in Wales in their day, and "what it is very few can tell." Camden, Ray, and Pennant call attention to a pool in the Conway, not far from Bettws y Coed, at the junction of Denbigh and Carnarvon, called *Llyn yr Afangc*, or the Beaver Pool; to another pool bearing the same name in Montgomeryshire (between Moat Lane and Llanidloes); and also to a little valley called *Nant Ffrancon*, in Carnarvonshire, the name being supposed by the natives to be a corruption of *Nant yr Afancwn*, or the Beaver Hollow. Pennant adds:—"I have seen two of their supposed haunts: one in the stream that runs thro' Nant Frankon, the other in the river Conway a few miles above Llanrwst; and both places, in all probability, had formerly been crossed by Beaver dams." Hoare points out that if the *Afangc* be identical with Gerald de Barri's *Castor*, then the latter cannot have been confined to the Teivi; and he quotes Owen-Pughe, who, in his Welsh Dictionary (published 1801), says that the *Afangc* "has been seen in this vale (*i.e.*, *Nant Ffrancon*) within the memory of man." Hoare concludes that the *Afangc* is nothing more than an obsolete or perhaps a local name for the Otter, and this view has received Harting's approval (*Extinct Brit. An.*, 37). The animal described by Giraldus is undoubtedly the Beaver. That old writer was not only an acute observer, he was a Welshman as well. It is therefore very difficult to think him mistaken when he describes the Beaver as being restricted to the Teivi; the more so since he obviously took much interest in that point. But at a still earlier period, in Romano-British times and probably for some centuries later, the Beaver had certainly a wide distribution in both England and Wales. Therefore, notwithstanding the fact that the modern animal mentioned by Owen-Pughe was in all probability nothing but an Otter, there is no reason why *Afangc* should not have been the name of the Beaver in North Wales long before the time of Giraldus; and this view would be in complete harmony with the statement of Price and Llwyd quoted above.[1]

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[1] Canon Fisher tells us that the use of *Afanc* = Beaver in Welsh is comparatively modern; it was used for an aquatic monster, like the Irish *piast*. Owen-Pughe dropped the reference to Nant Ffrancon in the second edition of his Dictionary (1832).

The Beaver has apparently given rise to a fair number of English place-names. Thus we have the name (and arms) of the town of Beverley, Yorkshire; Bevercoates, Notts; Beversbrook, Wilts; Beverstone, Gloucestershire; the Barbourne or Beaverbourne, associated with Beaver Island and Beverege, Worcestershire; and Beverley Brook, Battersea (mentioned as *Beferith* in an original charter, dated A.D. 693).

With regard to Scotland the documentary evidence is less satisfactory than that respecting Wales. The earliest record appears to be that described by E. R. Alston as follows:—"In a capitular of export duties of David I., 1124-1153, skins of *Beveris* are included (*Acts Parl. Scot.*, i., 303); but they are not mentioned in a similar Act of 1424. The late Prof. Cosmo Innes, however, pointed out to me that too much trust must not be given to these documents, as the lists of commodities appear in some cases to have been adopted from similar English or foreign enactments."

Notwithstanding the non-appearance of the Beaver in the Act of 1424, Boethius, in 1526, included it in his list of the animals which abounded around Loch Ness, and whose furs were in request for exportation; and Bellenden, who published a vernacular translation of Boethius in 1536, accepted the "Bevers," although he omitted the stags, roe-deer, and otters of the original list. Little can be based upon this, however, for, as Neill pointed out (*op. cit.*, 179), Bellenden's translation shows carelessness and looseness; moreover, Boethius himself may have quoted the Beaver merely from hearsay. In 1684 Sibbald contented himself with saying:—"Boethius dicit fibrum seu castorem in Scotiâ reperiri; an nunc reperiatur, nescio."

Some further evidence that the Beaver survived in Scotland until the historic period may perhaps be found in the *Losleathan* tradition. Neill (*op. cit.*, 181) says that Walker used to mention in his lectures that "the Scots Highlanders still retain, by tradition, a peculiar Gaelic name for the animal." This was confirmed by Dr Stuart of Luss, a well-known Celtic scholar, who in a letter to Neill wrote:—"The name is *Losleathan*, derived from *los*, the tail, point, or end of a thing, and *leathan*, broad; or *dobhran losleathan*, the broad-tailed otter." Stuart added that he "recollected to have heard" of a tradition among the Highlanders "that the beaver, or broad-tailed otter, once abounded in Lochaber." As Neill says, "It is rather a puzzling circumstance, that, in the poems of Ossian, no mention should occur of the *losleathan*, an animal whose manners must have struck with admiration a rude people, and whose fur must have been invaluable in the eyes of the Fingalian heroes and their ladies." C. H. Alston, in his review of recent inquiries respecting this tradition, says:—"To the most intelligent and well-informed Gaelic-speaking Highlanders of to-day the words *Dobhar-chu* or *Dobhran-losleathan* appear to have but the vaguest or no significance; at most one will be told 'a kind of otter.'" He adds:—"One cannot but infer that the existence of the beaver in Scotland must be relegated to a very remote period indeed, and that they were extinct long before the time when they disappeared from Wales. Possibly, too, they may have been always sparsely distributed, and confined to a few favoured localities." It is sufficient to say here that we are in full agreement with these conclusions.

The history of the Beaver in western continental Europe resembles that which we have traced in Britain. The animal was widespread, although apparently scarce, during the Pleistocene. It became quite common in the Neolithic period, when it appears to have played no unimportant part in bringing about the swampy conditions favouring the growth of peat. Its remains have been found, in abundance and at a large number of localities, beneath the peat-mosses of Skandinavia, Denmark, Germany, Holland, Belgium, and France. In Denmark it became extinct before the historic period.[1] Elsewhere, in face of advancing civilisation, and partly because of direct persecution, colony after colony has vanished, and the species has been brought close to total extinction. In the eighteenth and the beginning of the nineteenth centuries, although its numbers had greatly diminished, colonies were to be found in favourable localities scattered over a very large portion of its former range. At the present time, so far as Western Europe is concerned, the Beaver is found only in South-western Norway, in the Elbe, and in the delta of the Rhone. In each of these localities it now enjoys theoretically complete protection. Of these living colonies, the Norwegian are the most important; Collett says several hundred individuals must be living there, and their numbers are not at present decreasing.[2]

The former wide distribution of the Beaver in continental Europe is witnessed, in all countries save Iberia, by a very large number of place-names; lists of these will be found in Linstow's paper cited above.

Distribution in time:—The geological history of *C. fiber* has been discussed under History and Distribution. The earliest known

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[1] Winge, *Vidensk. Medd. Naturh. Foren. Köbenhavn*, 1904, 224 and 303; and Collett, *Norges Pattedyr*, 188.

[2] For a valuable summary of facts relating to former and present distribution of Beavers and for Bibliography, see O. von Linstow, *Die Verbreitung des Bibers im Quartär. Abh. u. Ber. Mus. Nat. Heimatk. Magdeburg*, 1908, i., 213-387. For accounts of living colonies the following may be referred to:—A. H. Cocks, *Zoologist*, 1880, 233, 497; 1881, 54; 1882, 15; 1885, 479; Collett, *Nyt Mag. f. Naturvidensk.*, 1883, p. 11; 1898, 35; *Bergens Mus. Aarbog*, 1897, and *Norges Pattedyr*, 1911, 186; Harting, *Zoologist*, 1886, 265; 1888, 182, 260; Mitford, *ibid.*, 1896, 184; Mingaud, *ibid.*, 1896, 184; *Bull. Soc. Ét. Sc. Nat. Nimes*, 1906 to 1910. The colony in the delta of the Rhone must be one of the most interesting in the world, for since there is little or no timber at hand, the Beavers must lead what is practically the life of a huge Water Rat. Nine captured when the water fell to an unusually low level in

British species is *C. veterior*, Lankester, from the Red Crag of Suffolk (Pliocene). In this, certain of the enamel folds of the molars are reduced to "islets" sooner than in *C. fiber*, and the premolars appear to have been relatively larger. In these characters this species makes some approach towards *Trogontherium*.[1] Jaws of another species, *C. plicidens*, Forsyth Major, first described from the Pliocene of the Val d'Arno, have been found in the Norfolk Forest Bed. This species is characterised by its broader incisors, slightly larger cheek-teeth, and especially by "the complex and elegant plication" of the enamel of the molars.[2]

Description:—The Beaver is a large heavily-built animal (head and body, 820; tail, 380; hind foot, 170), with a rounded water-rat-like head, short, heavy limbs, and remarkably modified tail. The upper lip is not cleft, and the nostrils are separated by a broad, naked pad. The eyes and ears are small: the latter are rounded, with little trace of tragus or antitragus, densely clad with hair within and without, and almost buried in the fur. The **hands** are relatively short but quite broad; their palms are naked, and for the greater part occupied by a pair of large, rounded pads, which fuse centrally and represent the posterior carpal pads of other rodents; there is little distinct trace of the anterior pads normally present; the digits, of which 3 and 4 are the longest, are short and armed with long, slightly curved, and rather flattened claws. The well-developed thumb bears a claw like those of the fingers. The **feet** are very large, about two and a half times as long as the hands, with broad, naked, scaly, and wrinkled soles, the pads being practically obsolete; each has five long toes, united by a strong web which extends to the bases of the claws; the latter are in general like those of the hand, but are especially large on digits 3 and 4; the claw of digit 2 is "double," a peculiar laterally compressed supplement springing from the ball of the toe beneath the claw proper and rivalling the latter in size; digit 4 is the longest, slightly exceeding 3 and 5. The **tail** is of exceptional strength, and highly modified as a swimming and steering organ; it is very broad

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the summer of 1893, and so exposing the entrances to the burrows in the banks, were purchased by the Zoological Society of London; of them six lived for some time in the Gardens at Regent's Park (*Proc. Zool. Soc.*, 1893, 612). Cocks informs us that these would not eat the rations usually supplied to the Canadian Beavers. Cocks has further kindly called our attention to a paragraph in the *Times* (30th December 1913), stating that a local sportsman had killed a Beaver near Dijon. If this example does not point to the existence of an inland colony, previously overlooked, then it must have followed the Rhone, and its continuation the Saone, for more than half the length of France.

[1] Lankester, *Ann. Mag. Nat. Hist.*, 1864, 355; Newton, *Pliocene Vert.*, 1891, 50; and Hinton, *Ann. Mag. Nat. Hist.*, January 1914, 186.

[2] Forsyth Major, *P.Z.S.*, 1908, 630; Hinton, *Ann. Mag. Nat. Hist.*, January 1914, 188.

and flat, its greatest width (about half-way down) equalling about one-third of its length; at its base it is densely furred, but elsewhere its covering consists of large, flattened scales, between which are scattered a few short, stiff hairs. The urino-genital organs, anal glands, and anus open into a cloaca, so that apart from the mammæ, of which the female has four, the sexes look alike externally.

The **pelage** consists chiefly of a very dense, long underfur (about 25 mm. long on back), with a far scantier growth of long, coarse hairs (50 to 60 mm. long); the latter are more abundant on the back, where they nearly conceal the underfur, but towards the flanks and on the underside they are more scattered, and leave the underfur plainly visible. The upper surfaces of the hands and feet are clothed with short hair, which completely conceals the scales.

The general **colour** of the head and body is a lighter or darker yellowish-brown, imparted chiefly by the longer hairs: the tint is usually duller below than on the back, and greyer or more pallid about the face and chin; the hairy parts of the hands and feet are brown; the naked muzzle pad, soles, palms, and the scaly portion of the tail are dusky. Partly or wholly albinistic specimens are sometimes met with, and their skins have sometimes a beautiful, iridescent lustre.

In addition to the family peculiarities described above, the strongly-built **skull** is characterised by the remarkable cellular excavation of the ventral surface of the basioccipital. The auditory bullæ are small, and each has a very long, tubular or spoutlike, external meatus. The zygomatic arches are very strong and widely expanded. The anterior palatal foramina are short and narrow; the tooth-rows are anteriorly convergent, and the pterygoid fossæ are deep, the short alisphenoid canals opening into their outer margins. The nasals taper posteriorly and terminate in the interorbital region well behind the ends of the ascending branches of the premaxillæ; in the American Beavers the nasals are shorter and terminate posteriorly at the level of the lachrymals.

The **mandible** is strong and deep; its rami are very firmly connected with each other: the strong coronoid processes rise considerably above the rounded condyles; the angular processes are rather small, and their posterior tips rise above the level of the cheek-teeth.

Dentition:—Both the incisors and the cheek-teeth when unworn show traces of a former, primitive, tubercular or brachyodont structure. The tips of quite unworn incisors are very slender, rounded, and coated on both their anterior and posterior surfaces with enamel; they show more or less distinct traces of apical tubercles and of grooves, which appear to represent the valleys which originally separated the incisor cusps; such parts are, of course, wholly ephemeral, and as vanishing structures betray a high degree of individual variability.

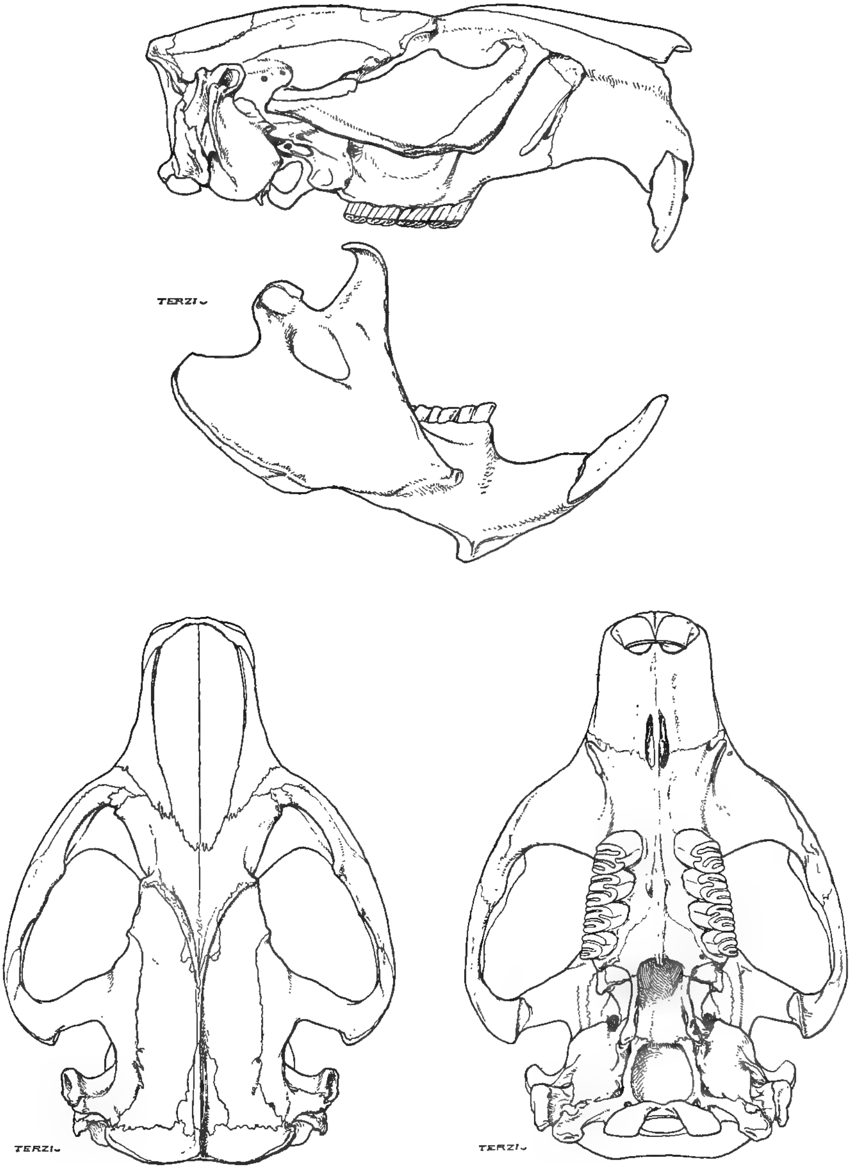

FIG. 96.—SKULL OF BEAVER (half life size).

Reproduced from Miller's *Catalogue of Mammals of Western Europe*, by the kind permission of the Trustees of the British Museum (Nat. Hist.).

The young incisor widens rapidly towards the pulp cavity; at a few millimetres from the unworn tip, the posterior enamel dies out, that of the anterior surface alone persisting; when wear reaches this point the chisel-like cutting edge, so characteristic of the adult incisor, is speedily produced. The milk-molars are in the general form of their crowns and roots strongly reminiscent of the teeth of more primitive Sciurids—and indeed of those of other ancient rodents, *e.g. Titanomys* among the *Lagomorpha*. They and the permanent cheek-teeth have, when quite unworn, tubercular caps; as the coronal tubercles wear away the prismatic structure of the deeper tooth-levels is revealed. In adult stages of wear the crowns of the cheek-teeth are squarish, the upper teeth being slightly broader than long, the lower rather longer than broad. Each upper tooth has typically three narrow re-entrant enamel folds starting from the outer border, and a single wider fold from the inner side. In lower teeth the pattern is similar, but the arrangement is reversed, the three narrow folds being internal, the single wider one external. All the folds persist until a very advanced stage of wear has been reached. The enamel is smooth and uncrimped, although, in aged specimens, a moderate plication sometimes appears in one or other of the folds. Short roots are developed late in life.

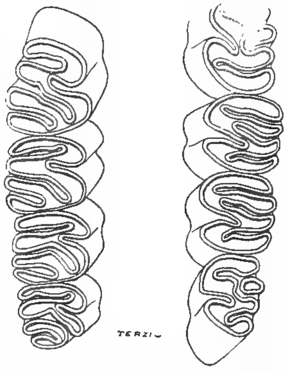

FIG. 97.—CHEEK-TEETH OF BEAVER (1½ times life size). Reproduced from Miller's *Catalogue*, by permission of the Trustees of the British Museum (Nat. Hist.).

Dimensions in millimetres of skull:—Adult, Mildenhall, Suffolk, Alluvium (B.M. 85.8.4.1)—Condylo-basal length, 142; zygomatic breadth, 106·4; interorbital constriction, 30·4; mastoid breadth, 69; occipital depth, 42·8; length and greatest width of nasals, 61·4 × 29; diastema, 48; maxillary tooth-row, 33·6; mandible, 109; mandibular tooth-row, 36·8.

Status:—*C. fiber* is now extinct in Britain. Attempts have been made to introduce the Canadian Beaver, and these have succeeded in showing that there is no serious difficulty as regards the possibility of acclimatisation. The Marquess of Bute introduced Canadian Beavers to Bute in 1874 and 1875; the colony, although now extinct, was in a thriving condition for a good many years, and the keeper, Mr J. S. Black, published an interesting account of it (*Journ. Forestry*, February 1880); this account has been fully quoted by Harting (*Extinct Brit. An.*, 52). Some were turned down at Sotherley Park, Wangford, Suffolk, but their dams were destroyed as an eyesore, and the last seems to have been killed about 1872 (Harting, *op. cit.*, 59). More recently Sir E. G. Loder has established a beaver-pond on his estate at Horsham, Sussex (*P.Z.S.*, 1898, 201), and this colony is still thriving.[1]

[GENUS TROGONTHERIUM.

1809. TROGONTHERIUM, G. Fischer von Waldheim, *Mem. and Soc. Imp. Nat. Moscow*, ii., 260 ; Owen ; Newton.

1823. *Castor*, G. Cuvier (in part) ; 1848, *Diabroticus*, A. Pomel ; 1862, *Conodontes*, Laugel.

TROGONTHERIUM CUVIERI, Fischer.

1823. TROGONTHERIUM CUVIERI, G. Fischer in Cuvier, *Rech. Oss. Foss.*, ed. 2, v., 59, based on a skull from sandy deposits of uncertain age near the Sea of Azof; Owen ; Newton.

1823. CASTOR TROGONTHERIUM, G. Cuvier, *Rech. Oss. Foss.*, ed. 2, v., 60.

1848. DIABROTICUS SCHMERLINGI, A. Pomel, *Biblio. Univ. Genève Arch. Sci.*, ix., 167.

1862. CONODONTES BOISVILLETTEI, Laugel, *Bull. Soc. Géol. Fr.* (2), xix., 709.

The largest British rodent, although long extinct, deserves a brief notice here. Fischer based his genus *Trogontherium* upon a fossil skull found in a sandy deposit exposed near the Sea of Azof. On the basis of drawings of this skull, sent to him by Fischer, Cuvier was unable to appreciate any generic distinction from *Castor*, although he estimated *Trogontherium* to have been fully one-fifth larger than the largest living Beaver. The subsequent discovery of fine material in English strata (and its able description by Owen and Newton) leaves no room for doubting the title of *Trogontherium* to full generic rank.

The dental formula is as in *Castor*. The incisors are much larger and less strongly curved. The cheek-teeth have triangular instead of squarish crowns, and they develop roots at a comparatively early age. The premolars are the largest, and are relatively larger than in *Castor*; m^1 and m^2 are small, while m^3 is somewhat larger, and when little worn is more complex. In the Beaver the cheek-teeth decrease in size progressively from before backwards. While the enamel pattern is essentially similar to that of *Castor*, the infolds soon lose their connection with the periphery of the tooth and become reduced to "islets" at relatively early stages of wear. The vertical extension of certain of the folds also is less, and they are soon entirely worn out.

The **skull** differs from that of *Castor* chiefly in that the ventral surface of the basi-occipital shows the normal median ridge and shallow lateral fossæ instead of the peculiar deep pharyngeal pit of the Beaver;

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[1] Sir E. G. Loder told Cocks (Jan. 1917) that his Beavers have ceased to breed for several years, but he has now introduced a young pair from the Zoo (keeping them carefully separate, however, from the old ones).

the bullæ are less inflated; the rostrum is stouter; the frontals longer, and their postorbital processes set further back; the parietals shorter; the anterior palatal foramina are nearer to the grinders, and are formed equally by the maxillæ and premaxillæ instead of almost wholly by the latter; the posterior edge of the palate is placed a little further forwards; and the maxillary zygomatic buttresses descend only about halfway down the maxillæ instead of to their alveolar margins (Newton, *op. cit. infra*).

Owen[1] referred some limb bones from the Norfolk Forest Bed, including a femur, tibia, astragalus, and calcaneum, to this genus, and he inferred from these bones that *Trogontherium* was less aquatic than *Castor*, and a swifter mover upon land. Quite recently another bone of the foot—the navicular—has been discovered, and a study of this has led independently to a similar conclusion.[2]

It is further of interest to note that an unworn incisor of *Trogontherium* presents ephemeral complications similar to those observed in *Castor* (p. 679 above); these complications point back to the common but very remote ancestor of all *simplicidentata* which must have possessed brachyodont and cuspidate incisors.[3]

T. cuvieri is known in Britain only from the Norfolk Forest Bed and from the High Terrace (early Pleistocene) of the Thames near Greenhithe, Kent. From the former horizon numerous remains have been obtained, including the magnificent skull found by Savin at East Runton and described by Newton in 1891 (*Trans. Zool. Soc.*, xiii., 165). Elsewhere in Western Europe the species has been met with in the Pliocene of St Prest, France, and in the early Pleistocene of Chelles, France, and Mosbach and Mauer, Germany. Remains of a smaller species, *T. minus*, have been described by Newton from the Red Crag (Pliocene) of Suffolk.]

SCIURIDÆ.

SQUIRRELS AND MARMOTS.

This large family, comprising more than fifty distinct genera and many hundreds of species, is distributed throughout the eastern and western hemispheres with the exception of their polar extremities, Madagascar, New Guinea, and Australasia. As now understood, it embraces all the living arboreal and terrestrial squirrel-like rodents, but does not include the volant genera, which are placed in a special family—the *Petauristidæ.* For our knowledge of the status of the group and the classification of its members we are chiefly indebted to the work of Winge, Forsyth Major, and Thomas.

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[1] Owen, *Geol. Mag.*, decade 1, vi., 1869, p. 52.

[2] Hinton, *Ann. Mag. Nat. Hist.*, January 1914, p. 190.

[3] Hinton, *op. cit.*, p. 189.

In a few respects the family stands on a somewhat higher plane than the *Castoridæ.* Thus the orbits are always partly roofed by the considerable supraorbital processes of the frontals. The auditory bullæ are divided internally by bony septa. The thumbs are in all reduced to short stumps. But apart from these characters and from the remarkable degree of specialisation evinced by the masseter muscles and the skeletal parts under their influence—a specialisation which, as shown above, is common to all Sciuromorpha—the members of this family retain many primitive features which stamp them as, in these respects, the least progressive of the Simplicidentata.

The **dentition** includes typically two functional premolars above and one below on each side, and these are preceded by well-developed and for a time functional milk molars; but in many forms the anterior upper premolar (p^3) is reduced or absent. The cheek-teeth, although showing from genus to genus a wide range of variation in structure, particularly in the degree of their progress towards lophodonty or hypsodonty, are always of a brachyodont type and are implanted solely by their distinct roots. In the **skull** the jugals are always large, articulating in front with the lachrymals; the bodies of the maxillaries are always shallow; and where least modified, as in the African *Euxerus* or the Asiatic *Eutamias*, the brain-case retains a form which recalls that of the least modified *Hystricomorpha.* The upper incisors extend backwards into the maxillæ, but terminate distinctly in advance of the premolars; the lower incisors terminate in the ascending rami of the mandible, but little above the molar level.

In the **skeleton** there are twelve or thirteen pairs of ribs; a well-developed clavicle; and the fibula is distinct from the tibia and does not articulate with the calcaneum. There is a well-developed *os penis;* Thomas, who calls this bone the *baculum*, has recently shown it to be subject to great and surprising variations of form within the limits of the old genus *Sciurus;* and the modern classification of this unwieldy group, now developing, will no doubt largely rest upon the characters afforded by this organ (*Ann. Mag. Nat. Hist.*, April 1915, 383).

The family dates from the Upper Oligocene, at least, in Europe and North America. Apart from some Sciurid remains from the Oligocene of Wight, which appear to represent a forerunner of *Sciuropterus* rather than a member of the present family, its British representatives belong to two genera, *Sciurus* and *Citellus;* both of them are members of the sub-family *Sciurinæ.* *Citellus* is only known from our Pleistocene deposits; but *Sciurus* has still a representative living in these islands.

GENUS SCIURUS.

1758. SCIURUS, C. Linnæus, *Syst. Nat.*, 10th ed., i., 63; genotype *vulgaris*, selected by tautonymy.

1893. APHRONTIS, Schulze, *Zeitsch. f. Naturwissensch.*, Leipzig, lxvi., 165; based on *Sciurus vulgaris.*

Squirrels of arboreal habits, whose general external appearance, cranial, dental, and other internal characters are closely similar to those of the well-known European and British species, are widely distributed throughout the wooded parts of Eurasia and the New World. They represent a very large number of species; and until quite recently all have been referred to the genus *Sciurus.* The latter indeed had swollen to such embarrassing dimensions that Miller found it "impossible to frame a satisfactory diagnosis of the genus *Sciurus*, or to estimate the number of forms that should be referred to the group."

Thomas (*op. cit.*, p. 384) describes the baculum of *S. vulgaris* (including *S. leucourus*) as being a "very characteristic bone, like a small spatula, or still more like a half-closed human right hand, the shaft forming the fore-arm, the blade of the spatula the hollowed palm, and a small pointed projection on the right side corresponding to an outstretched thumb." Bacula of this type are found also in the two other Palæarctic species—*S. persicus* and *S. lis;* in all the American species—

so far as Thomas has been able to examine them in this respect; and "remarkable to say" in the Giant Squirrel (*Reithrosciurus*) of Borneo. In all the Indian and Malayan species the baculum is more complex, being provided with a more or less well-developed, separate cutting-blade, articulated with and attached to the shaft of the bone by ligaments; Thomas has therefore removed all these arboreal squirrels from the genus *Sciurus*, reviving Gray's *Callosciurus* for one section, and instituting his own genus *Tomeutes* for another.

A few weeks after the publication of Thomas's paper, Allen (*Bull. Amer. Mus. Nat. Hist.*, xxxiv., May 1915, p. 171), reviewing the South American *Sciuridæ*, removed "the genus *Sciurus* from the American biota" and referred all American squirrels to other generic divisions. Whether such a drastic course is quite justified may be open to some question; but as to its convenience there can be none.

The genus *Sciurus*, as understood at present, therefore comprises merely four living species, viz., *S. vulgaris*, ranging through the whole of Europe and a large part of northern and central Asia; *S. leucourus*, inhabiting Britain and Ireland; *S. persicus*, from Asia Minor and Persia; and *S. lis*, an inhabitant of Japan. In addition several European fossil species, dating from the Eocene onwards, are at present referred to "*Sciurus*"; but in their case the generic name is merely a confession of ignorance; for the fossils hitherto found, although ample to demonstrate the former existence of species with jaws and teeth more or less similar to those of living *Sciurus*, are wholly insufficient as a basis for determining the fine generic distinctions of modern mammalogy.

The leading **characters** of the genus *Sciurus*, as defined above, may be summarised as follows:—Squirrels of essentially arboreal habits, medium size, and typical outward appearance; with a bushy, vertically compressed tail, whose length exceeds half the length of the head and body. The **baculum** is simple, as above described. The **skull** is deep, with a well-arched and relatively capacious brain-case, and a short rostrum; the supra-orbital outgrowths are large and terminate behind in slender postorbital processes. In the **dentition** the incisors are strongly compressed, much deeper than broad in transverse section. The cheek-teeth are tubercular, brachyodont, and rooted. In the upper jaw, the anterior premolar (p^3) is very small and simple, and has little functional importance; the other teeth ($p^4 - m^3$) are subtriangular in form and have two low rounded tubercles (4 and 5), each supported by a slender root, on their outer borders; with these tubercles are more or less evident traces of the cusps 1, 2 and 3; on the inner side of each tooth is a single relatively lofty cusp, formed by the fusion of at least three elements, and supported by a long and stout root; the base of this inner cusp is connected by low transverse ridges with the bases of the outer cusp 4 and 5; and these transverse ridges form the forward and backward margins of a spacious and rather deep central valley. The lower cheek-teeth ($p_4 - m_3$) are quadratic and four-rooted; each has two low rounded tubercles on the outer side; a shallow basin-shaped concavity occupies the greater part of the surface of the crown; the inner margin of the basin is crenulate behind but anteriorly it rises up into a lofty terete cusp. When the teeth are fitted together, the prominent inner cusp of each upper molar is seen to work in the basin-shaped concavity of the opposing lower tooth like a pestle in a mortar; while the lofty antero-internal cusp of each lower molar shears within and between the internal cusps of two contiguous upper molars. As explained by Forsyth Major (*Proc. Zool. Soc.*, 1893, 181), squirrels with cheek-teeth like those of *Sciurus* may be regarded as representing, in the molar evolution of the *Sciuridæ*, an intermediate stage, which connects the most brachyodont forms (*e.g.*, the Eocene *S. spectabilis*, Major, the living *Reithrosciurus* of Borneo and *Protoxerus* of Africa) with the most hypsodont groups (the Ethiopian *Xerus* group, and the Oriental *Menetes* and *Rhinosciurus*).

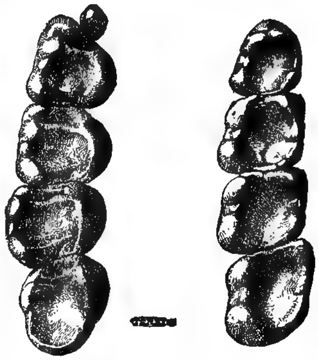

FIG. 98. — CHEEK-TEETH OF SQUIRREL (*Sciurus vulgaris*). × 5. Reproduced from Miller's *Catalogue*, by permission of the Trustees of the British Museum (Nat. Hist.).

THE BRITISH OR LIGHT-TAILED SQUIRREL.

SCIURUS LEUCOURUS (Kerr).

1769. SCIURUS VULGARIS, John Berkenhout, *Outlines Nat. Hist. Great Britain and Ireland*, i., 6; and of most subsequent writers up to and including Thomas, *Zoologist*, 1898, 100, but not *S. vulgaris* of Linnæus.

1792. SCIURUS VULGARIS LEUCOURUS, Robert Kerr, *Animal Kingdom*, 256; described from England; Miller, *Catalogue Mamm. West. Europe*, 907.

1899. SCIURUS LEUCURUS, G. E. H. Barrett-Hamilton, *Proc. Zool. Soc.*, London, 17th January 1899, 3; Millais; Trouessart (sub-species of *vulgaris*).

L'écureuil of the French; *das Eichhörnchen* of the Germans; these, with, no doubt, many local names in each language, strictly refer to the nearly allied continental species *S. vulgaris*, and not to the present animal at all.

The quite simple **synonymy** of this animal is due to its differentiation from the Common Squirrel of continental Europe, *S. vulgaris* of Linnæus, an animal which, through its numerous sub-species, has accumulated a host of technical names.

Terminology:—"Squirrel," with many variations in spelling, has been the general name of this animal from the Norman Conquest. The Middle English form is "squirel" or "scurel"; *e.g.*, Wright's *Vocabulary*, 759, 29:—"*Hic scurellus*, a scurelle." (Chaucer *Rom. of the Rose*, 1471) has—"There might menne does and roes ysee, And of squirrels full great plentee, From bough to bough alway leping"; and again (*Parl. Foules*, 196) he speaks of "Squirrels, and beastes small of gentle kind." The word appears to have been derived from the Norman French *esquirel;* this and the Old French *escurel*, *escuirel* and *escuireul* (in thirteenth century, *MS.*, *Cocks*) came from the late Latin *scurellus* or *scuriolus*, diminutives of the Latin *sciurus*. The latter is derived from the Greek σκίουρος, the literal meaning of which is said to be "shadow-tail"—though this is probably due to popular etymology, the real origin of the name not having been certainly found.

According to Somner (*Dict. Saxonico-Lat.-Angl.*, 1659; quoted by Bosworth, *Anglo-Saxon and Engl. Dict.*, 1868, 20), the Anglo-Saxon name for the Squirrel is *Acwern;* Bosworth (*op. cit.*, 251) also gives *wern*, without the prefix *ac*. *Acwern* appears to be the equivalent of the German *Eichhorn*, the Danish *Egern*, and the similar names in other Teutonic languages. In each of these cases the prefix means oak-tree; but, as Keller (*Die Antike Tierwelt*, 181) points out, the animal has no particular love for the oak, and the real etymology is unknown. As regards *acwern*, if *ac* may once have signified "tree" in general,[1] rather than oak in particular; and if *wern* can be derived from the Anglo-

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[1] For a discussion of the changes in meaning of the names "fir," "oak," and "beech" in various languages, see Max Müller, *Lect. on Science of Language*, ser. 2, 1864, 216, 219, and 222.

Saxon *wær*="wary," or *wærgenga*, which means "one who retires to lonely places, such as a wild beast," then the compound *acwern* might signify literally "the animal which takes refuge in trees."

Local names:—(Non-Celtic)—*Scopperil* of Yorkshire; thus "He went up the tree loike a scoperil" (*Yorks. Weekly Post*, 12th June 1897). The original meaning of this word is given by Wright as a spinning-top or teetotum. It is a Skandinavian word and a diminutive formed from "*skop*," the root sense of which was the "skipper" from *skopa*, to skip, of the Swedish (dialect), or "spinner" from the Icelandic *skoppa*, "to spin like a top." The form *scoperil* was corrupted into *scropel*, also a Yorkshire form given by Wright; *e.g.*, "I can hear th' boggarts creeping, wick as scropels, fro' roof to cellar" (Sutcliffe, *Shameless Wayne*, 1900, vii.).

Scrug of Hampshire (Wright) with its corruptions *scug*, *skug*, or *skugg*, appears also to be of Skandinavian origin; this name, in one form or another, is in very general use throughout the greater part of England, and Benjamin Franklin has recorded the fact that in his day *skugg* was the common name for all squirrels in London.

Swirrel, *sweril*, and *swirl* of the northern dialects are, of course, merely variants or corruptions of squirrel.

Con, or *conn*, is a name found in the northern dialects; the earliest reference cited in the *New Engl. Dict.* is to Burel's *Pilgremer* (in Watson, *Coll. Poems*, ii., 20), dating from 1600, in which are the lines:—"There wes the pikit porcupie, The cunning & the con all thrie." Harvie-Brown states that the word is, or was, used in north Lancashire, southern Cumberland, Westmoreland, and through the south of Scotland; he says that the word is unknown in the north of Cumberland, and cites Ferguson, who gives (*Dial. of Cumberland*) "*con*, a squirrel's nest; in Lonsdale, the squirrel," and who refers it to the Welsh *cont*, a tail. Harvie-Brown further states that the word is now quite extinct in southern Scotland, although it was known to Alastair M'Donald, who, in 1771 translated the Gaelic *feoirag* as "a squirrel or *conn*." According to Harvie-Brown, Gaelic scholars are of opinion that the word is a contraction of the Gaelic *coinein*, a rabbit, which they think is a diminutive of *cu*, a dog. But, as the quotation from Burel given above shows, early writers distinguished the *con* from the *cuning*.

The nest of the squirrel is called a *dray*, *drey*, or *drug* in many of the southern and midland counties of England (see White's *Selborne*, Bennett's ed., 1837, 460[1]). This word is of uncertain origin, but may have been derived from the Anglo-Saxon *dragan*, to draw.[2] According to the *New Engl. Dict.* it first occurs in Topsell, who mentions "the draies of squirrels."

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[1] In footnote 2 to the page cited, Mitford states that the nest is called a *bay* in Suffolk.

[2] We would suggest a possible derivation from the Anglo-Saxon *drig*, *dreg*, *drug*, or *dryg*=dry; the *dray* being the place where the squirrel keeps high and dry.

(Celtic):—Irish—*Feoróg* (MacBain); *Iora* or *Ir* (the latter obsolete according to C. M. Robertson); *Easag* or *Easog* (MacBain); "*Cricháran*" (? *Craobharan*).

Scottish Gaelic:—*Fheòrag* or *feòrag*; *Easag* (C. H. Alston).

Welsh:—*Gwiwair* (Pennant); or better *Gwiwer* (Fisher).

The Celtic names for the squirrel are puzzling and their literal translation difficult. The difficulty seems to arise largely from the fact that squirrels have, at all times and among all peoples, been often confused with martens, weasels, and even with foxes.

Feórag (with its variants) may be translated as "the little inquisitive one"; but if it has been derived from *fhiodarag* it would signify merely a "wood- or tree-animal." *Iora* and *ir* also indicate the inquisitive nature of the animal, and O'Mulrennan (*fide* Warren, in Harvie-Brown, *MS.*) was inclined to explain *feórag* as a derivative—*f-iorag*—*f* being prefixed, in accordance with the common Celtic practice of prefixing *f* to a word commencing with a vowel, and the diminutive *ag* being suffixed.

Easag, or *easog*, is perhaps more properly applicable to mustelines; for in Irish *easag* is the name of the Stoat, while *easag-cram* signifies the "tree-weasel" or Marten. But no doubt *easag* has often been used for the squirrel and it is used for pheasants as well.

"*Cricháran*" appears in the list of wild animals produced before the king at Tara, as the ransom of Finn MacCumhaill, given in a *MS.* poem dating from before A.D. 1000 (see Wilde, *Proc. Roy. Ir. Acad.*, vii., 181). The word "*crichárán*" appears to be unknown in either Irish or Scottish Gaelic; but James Macpherson (*fide* Harvie-Brown) thought it to be possibly a mis-reading of *craobharan* or "the tree-animal."

Distribution:—This Squirrel is confined to the British Islands, where it is common in all wooded localities of Great Britain, except only those in which its numbers are kept in check by persecution. Where there are no woods it is absent, and it disappeared almost from Scotland, and entirely from Ireland. But it soon appears in newly planted districts, and has been reintroduced in both the last-named countries. It is increasing in the newly wooded districts of Wales, where it is common up to 1000 feet (Forrest), and ascends to 1400 feet in Aberdeen (Dickie).[1] It comes quite close to towns, and may even enter public gardens connected with them.

Its **status** in **England** requires no special comment, except as regards Cornwall and "Lakeland." In the former it is stated to be extending its range. Although abundant throughout the Truro and

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[1] Dickie, *Botanists' Guide to Aberdeen, Banff, and Kincardine*, 1860; quoted by Harvie-Brown, *op. cit. infra*, 151.

Falmouth district, it seems to be absent from the west and south-west, as well as from many parts of the east and north (Clark). In Lakeland, Macpherson seems to suggest that it may not be indigenous, and Tate says that it is of comparatively modern reintroduction in many parts of the north of England (*Proc. Berwickshire Field Club*, i., 440). But Macpherson admits that a little more than a hundred years ago it was certainly well established in Lakeland, that it is represented in armorial bearings of the county families, as well as on the Runic Bewcastle Cross, and that its skin was known in commerce at Berwick in 1377; the skins, however, may have been imported. It is common in plantations in Anglesey and Wight.

Its distribution in **Scotland** has been investigated by Harvie-Brown, whose lengthy and erudite paper[1] on the subject is difficult to summarise. According to this writer there is no record of its existence as an indigenous animal south of the Firths of Forth and Clyde, other than two vague allusions in the *New Statistical Accounts of Berwickshire* (p. 299, 1841) and *Roxburghshire* (p. 4, 1841). To these must be added the statement of Sibbald in 1684 (*Scotia Illustrata*, 2, ii. 11), that it occurred *in meridionalis Plagæ Scotiæ Sylvis*, a statement which Harvie-Brown appears to consider as in itself of little or no value. Even, however, if Sibbald's statement be accepted, as it is by W. Evans, the animal must have practically disappeared in the lowlands soon after Sibbald's time, retiring to or lingering in the shelter of the forests north of the Firths of Forth and Clyde. North of these Firths, as shown by the records, it appears to have been widely spread in the Middle Ages, and was found by Sir Robert Gordon in 1630 even in Sutherland (*History of Earldom of Sutherland*, 1630, not printed from MSS. until 1813). Subsequently, however, it became very rare, if not extinct, in the greater part of the country, succumbing to the universal destruction of forests, which banished also the roe-deer and capercailzie. But there is every reason to believe that it lingered on in one or two favoured localities, as in Ross-shire, to the end of the eighteenth century, and in Ayrshire to about 1839 or 1840. In the great old forest of Rothiemurchus it probably never became entirely extinct, so that a remnant of the true ancient Scottish race issued thence to colonise the new woods and plantations. Finally, in the eighteenth and nineteenth centuries, it was reintroduced from England in many centres, as notably at Dalkeith, Midlothian, about 1772, by Elizabeth, Duchess of Buccleuch (W. Evans); and with the growth of plantations has now gradually spread over the whole mainland, having re-entered Sutherland about 1869 (Alston and Harvie-Brown, *Proc. Nat. Hist. Soc., Glasgow*, ii., 144) and South Ayrshire in 1877 (see Alston; Harvie-Brown, vi., 35;

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[1] J. A. Harvie-Brown, *Proc. Roy. Phys. Soc., Edinburgh*, v., 343; vi., 31 and 115.

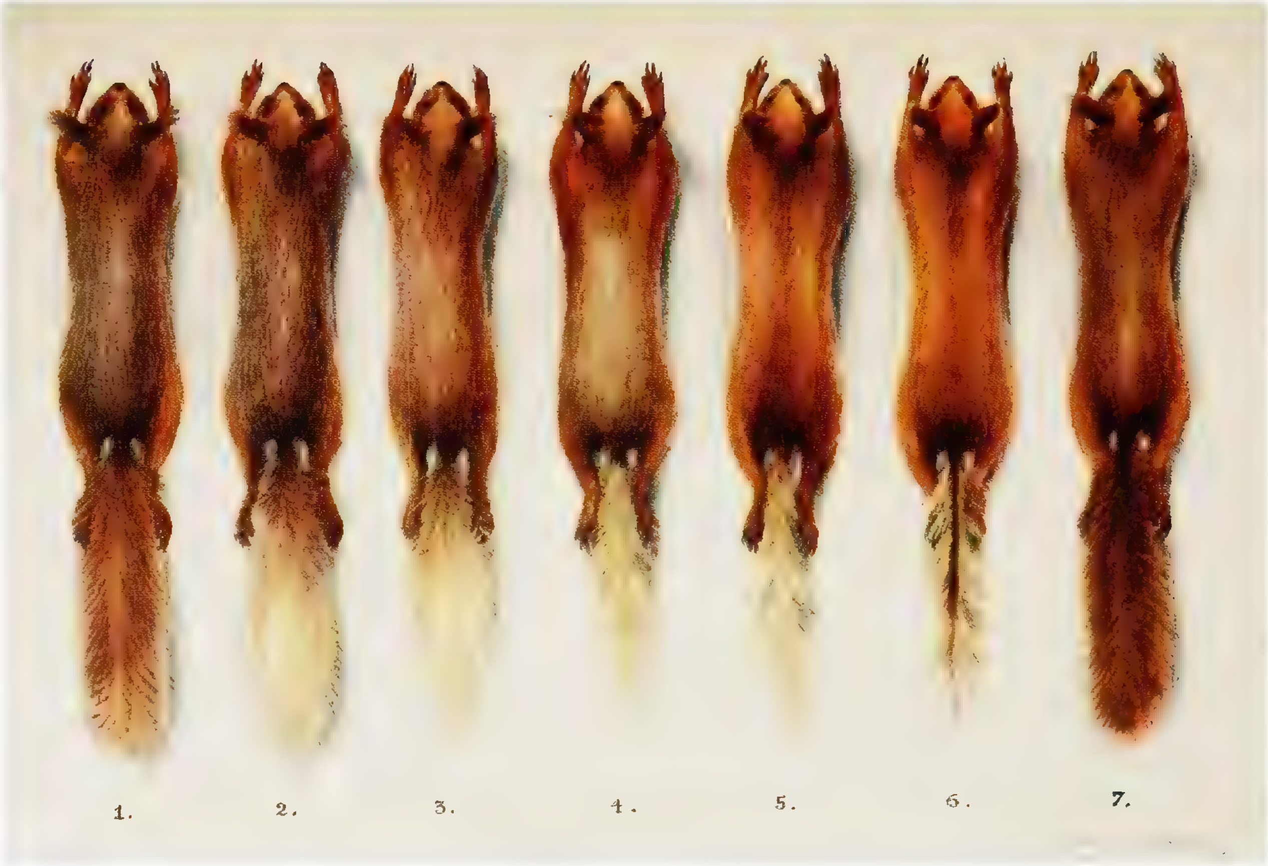
W. Evans). Perhaps in some cases introductions were made from Continental Europe (Harvie-Brown, vi., 148); but such continental squirrels would have, of course, been *S. vulgaris*, of which no Scottish example has been identified.

In **Ireland** it is now widely distributed, and common in a number of localities in many counties; but Barrington (*Sci. Proc. Roy. Dublin Soc.*, November 1880, 615-631) has shown that its presence may in all cases be traced to introductions, none of which took place earlier than about 1815. He could find no trustworthy evidence of the presence of the animal in Ireland before the nineteenth century, and believed that it could not have been indigenous.

The following twenty counties were scheduled by Barrington as harbouring Squirrels in 1880:—Wicklow, Dublin, Kildare, Wexford, Carlow, Kilkenny, Queen's, King's, Galway, Roscommon, Longford, Westmeath, Donegal, Antrim, Tyrone, Monaghan, Londonderry, Down, Armagh, and Louth. At that time there was no evidence of their occurrence in the remaining twelve counties of Fermanagh, Leitrim, Cavan, Meath, Sligo, Mayo, Clare, Limerick, Kerry, Cork, Tipperary, and Waterford.

Since 1880 Squirrels have vastly extended their range in Ireland, helped no doubt by further introductions—as in Wexford, where they were introduced near New Ross, and have, besides, entered the north of the county from Co. Wicklow, overrunning it in two directions until their two forces met. Further they have colonised a new county—Waterford — where they were reported to Barrett-Hamilton from Faithlegg in 1896 by Ussher. Adding Tipperary, in many parts of which they are plentiful, they are now in occupation of the whole south-east of Ireland. About the year 1895 they were seen at Glasslough, Co. Fermanagh (James Brodie, Keeper, *in lit.*, 30th January 1895), as well as at the Deeps (Col. C. S. Walker, *in lit.*, 21st April 1896), and at Edermine (Sir J. Power, *in lit.*, April 1898), the two latter localities being in Wexford. By the same date they had quite overrun Co. Meath (Rev. J. B. Gibson, *in lit.*, 26th December 1895). They have also appeared in the west, having been reported from Kerry (Jenner, *Field*, 24th October 1908, 721), and there can be no doubt that their presence may be confidently expected in the immediate future in all the wooded parts of Ireland.

Although Barrington could not have justifiably decided otherwise on the evidence which he had before him, there are now available a number of records pointing to the presence of the Squirrel as an indigenous member of the Irish fauna in historical times, and thus confirming the suggestion made previously by Harvie-Brown (*op. cit.*, p. 80). In the numerous lists of the exports of Ireland which have now been published, and which date from the earliest times for



Skins of British Squirrel—*Sciurus leucourus.* Seasonal Change.

1. January. 2. March. 3. May. 4. June. 5. July. 6. September. 7. November.

which we possess any information, even from before the Norman Conquest, furs and skins always hold a prominent position (*Sinn Feinn*, 1908, 130-138). The names of these are given in some detail, and we find that of the Squirrel included, besides Horse, Ox, Sheep, Lamb, Deer, Wolf, Marten, Otter, Wild Cat, Hare and Rabbit (*op. cit.*, 130; also Mrs Green's *The Making of Ireland and its Undoing*, 1908, 73).

In the thirteenth century there are several allusions to a tax on Squirrel skins, as at Waterford, where in 1243 the citizens were allowed customs for walling the town, including those on the skins of Squirrels (*Cal. Doc.*, *Ireland*, i., 2613). A similar grant was allowed to the men of Drogheda in 1278 (*op. cit.*, ii., 1517), of Cork in 1284 (*op. cit.*, iii., 520), of Fethard in 1292 (*op. cit.*, 1015), and again of Waterford on 28th June 1291 (*op. cit.*, 917).[1] On 28th April 1286, Thomas Fitzmaurice was granted customs to enable him to wall Tralee and Moyal (Mallow); these customs included a tax of one halfpenny on every hundred skins of squirrels (*Proc. Roy. Soc. Antiquaries, Ireland*, xxiv., 16). Quite three quarters of Ireland are thus represented, and the records indicate a wide distribution, including the whole island except the north and north-west.

At that period the fur of the Squirrel was used for trimming the robes of superior Irish officials, as mentioned by Froissart in describing the visit of Richard II.; and Barrett-Hamilton was informed by Captain Philip Hore, the well-known author of the *History of County Wexford*, that the records of the reign of Edward I. (1272-1307) include many notices of the prices paid for the skins, which are clearly distinguished from those of the Marten and "Weazil."

A particular use of the fur of the Squirrel may be cited from the accounts of the Lordship of Carlow, made out between 1279 and 1284 for the owner, Roger Biford, Earl of Norfolk, who died in 1306 (see James Mills, *Proc. Roy. Soc. Antiquaries, Ireland*, April 1892, 50-56). So well-known was the fur that it had two distinct names, being called "Strangling,"[2] when at its best as between Michaelmas and winter, and "Roskyn," perhaps from its russet colour, in summer.

There is a comprehensive list of the fur-bearing animals of Ireland and its other natural products in the *Libel of English Policie*, written about 1430, and dealing with the trade of Chester. The passage may be quoted *in extenso*:—

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[1] For many references Barrett-Hamilton was indebted to the kindness of T. J. Westropp, who met with them during his studies of Irish History.

[2] A name also known in Scotland (variously spelt as "Strandling," "Strandeling," "Strandlyn," "Stranling," or "Stradling") in 1328 and 1329; see Harvie-Brown, *op. cit.*, vi., 38. One might hazard the suggestion that "Strandlings" signified "skins coming from beyond the seas," and that the term was equivalent to the "Calabar" of modern furriers.

"I caste to speke of Irelonde but a lytelle,
Commoditees yit I woll entitelle,
Hydes, and fish, samon, hake, herynge,
Irish wollen, lynyn cloth, faldynge,
And marternus gode, bene here marchandyse,
Hertys hydes, and other of venerye,
Skynnes of otere, squerel, and Irysh hare,
Of shepe, lambe, and fox, is here chaffare,
Ffelles of kydde and conies grete plente,
Of silver and golde there is the oore."[1]

At about the same time one Nicholas Arthur of Limerick is definitely mentioned as trading in horses, falcons, skins of otters, martens, squirrels, and other soft-furred animals (*Arthur. MSS.*, Lenihan, Limerick, 369), his first trading voyage having taken place in 1438. Finally, in the late fifteenth century, the skin of the Squirrel was included by Hakluyt amongst the exports of Ireland.

The above records are ample and conclusive as to the former existence of the Squirrel in Ireland. They are quite satisfactory on all the points which might have been subject to error, *e.g.* there is no possible confusion with any other animal, and the export and import trades are not confused, a matter of importance when it is remembered that there was in mediæval times a considerable import trade in Squirrel skins.

Exactly when the animal became extinct is still a matter of conjecture, but, since it must have previously reached a point at which its pursuit became unprofitable, documents may at any time be discovered throwing light upon it. In the meantime there is little to bridge the gap between the end of the fifteenth century when the squirrel must have been abundant and its reintroduction about 1815. Its inclusion in O'Flaherty's list of the animals of Western Connaught in 1684 and in Keough's *Zoologica Medicinalis Hibernica* (p. 83) in 1739 are, if unsupported, records of quite doubtful value. Certainly, however, they gain in authority from the other records by which they are now known to have been preceded; but it would probably be unsafe to argue from them, as some do, that these two records indicate that the Squirrel never became altogether extinct in Ireland.

Apart from the persecution of man, the cause of the disappearance of the Squirrel from Ireland must always remain doubtful. But the universal destruction of woods, into the remnants of which the beasts of prey—stoats, martens, and perhaps wild cats—must have gathered in unusual numbers could have had no small influence.

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[1] *Political Songs* (Rolls Series, ii., 185, 1861): reprinted at p. 414 of *Ireland, Industrial and Agricultural*, published by the Department of Agricultural and Technical Instruction for Ireland, Dublin, 1902; also in Joyce, 433.

The Squirrel is absent from Man (Kermode in Ralfe) and all the Scotch Islands, except Bute, where it is said to have been introduced about 1873 (Harvie-Brown), but is now extinct.

Distribution in time:—Notwithstanding the great antiquity of the genus, it appears to have left but few traces of its former existence in the fossiliferous deposits of Britain. Apart from the early Tertiary remains noticed above, our knowledge is limited to the scanty information gleaned from the late pliocene Norfolk "Forest Bed." Heer first noticed that some fossil fir-cones from this deposit appeared to have been gnawed by Squirrels (Lyell, *Antiq. of Man*, 1863, 215). Later, Newton (*Vert. For. Bed.*, 92) ascribed a humerus in the Green collection (British Museum) to *S. vulgaris;* this specimen is reputed to be from the Forest Bed of Ostend, Norfolk, but its age, as Newton pointed out, is quite doubtful, there being a much more recent alluvial deposit in the vicinity from which Green also collected many specimens. Quite recently, however, a premolar has been found in the Forest Bed at West Runton, and this proves the late Pliocene species—*S. whitei*, Hinton (*Ann. and Mag. Nat. Hist.*, January 1914, 193)—to have had a more bunodont and primitive dentition than *leucourus* or *vulgaris;* when better known, *S. whitei* will very likely prove to belong to a genus distinct from *Sciurus* in the strict modern sense. No trace at all of the genus has been so far discovered in the British Pleistocene, a fact to be ascribed to its arboreal habits, and the consequent remoteness of the chance of entombment rather than to its absence from our primeval forests. Woldrich has referred some fragments from the late Pleistocene of Zuzlawitz, Bohemia, to *S. vulgaris.*

Description:—The British Squirrel is a slenderly built rodent, characterised in life by its peculiarly graceful and elegant appearance. Its neck and limbs, being much less completely invested in the common integument of the trunk, are more obvious externally, and apparently longer than in *Muridæ.*

The head is moderately large, rounded behind, with a narrow, rather short, but relatively deep rostrum. The muzzle, except at the margins of the nostrils, is hairy; the median walls of the nostrils are narrowly but deeply separated by an upward continuation of the lip-cleft. Besides the whiskers, which are numerous stout, black hairs, of which some surpass the head in length, tactile hairs occur in three positions, viz. (1) above the eyes, where there are two or three long and rather fine black vibrissæ; (2) on each cheek three or four similar black hairs are placed below the eye, on the level of a line drawn from the mouth to the base of the ear; and (3) on the ventral surface, just in front of the throat, are three strong, light-coloured vibrissæ.

The eyes are large, black, and prominent. The **ears** are erect, long (overlapping the eyes when laid forwards), rather narrow, and with rounded tips; externally they are clothed with abundant long hairs, which, from early winter to late summer, project beyond the tips as conspicuous tufts or pencils; the inner surfaces have a thinner covering of shorter and finer hairs. In each ear the lower portion of the anterior margin is curled backwards above the small tragus; while the basal half of the posterior margin is curled forwards to form a large and strong triangular flap, which conceals the feeble antitragus, and is capable of closing the meatus from without.

Each **hand** has five prominent and cushioned pads: of these three are anterior and relatively small, and are placed between the bases of digits 2 and 3, 3 and 4, and 4 and 5, the median one being more advanced than the others, which are level; the two posterior pads are larger and of square or somewhat rounded form. Of the digits, 4 is distinctly the longest, 3 is slightly shorter, 2 reaches the ball of digit 3, and 5 is very slightly shorter. These digits are long and free, capable of wide-spreading, hairy above, feebly annulated and naked below, and each is armed with a moderately long, sharp, curved, and strongly compressed claw. The thumb is reduced to a minute vestigial tubercle, which is placed beside the postero-internal carpal pad, being scarcely one-fourth of the size of the latter, and it bears a small flattened nail.

In comparison with the fore-limbs the legs appear disproportionately long and heavy. In each **foot** there are four small pads placed between the bases of the digits; there is no trace of posterior pads. The toes are quite like the fingers in general character, and each, including the hallux, is armed with a long and strong claw; the claws are, however, somewhat stouter than in the hand. Digits 3 and 4 are nearly equal in length, 4 being, however, very slightly the longer; 5 reaches to the base of the ball of 4; 2 is slightly longer than 5; and digit 1 is well-developed, reaching a little beyond the base of 2. Both the palms and the soles are naked in summer typically, the skin between the pads being wrinkled and very finely granular; but with the approach of winter they acquire a more or less dense and extensive covering of short and fine fur.

The **tail** without the terminal hairs is about equal to the body; with the hairs about equal to the body and head in length; it is cylindrical and smooth skinned, not scaly. It is clothed with a dense, woolly underfur, and with very numerous long, soft, but strong hairs, which, rising principally from its back and sides, grow outwards and backwards horizontally, and form a dense bilaterally symmetrical fringe or brush. When fully haired the tail as seen from above or below is strikingly broad, while in side view it appears to be greatly flattened or compressed.

The female has eight mammæ, arranged in one pectoral, two abdominal, and one inguinal pairs.

Pelage:—The fur is soft and fine, not spiny. It is comparatively short on the face, as well as on the belly, throat, inner surfaces of the limbs, and over the hands and feet. Passing backwards from the forehead, it becomes gradually longer and denser on the back and flanks towards the rump and tail, where it is most luxuriantly developed, and where the woolly underfur is most conspicuous. The hairs also attain a remarkable length upon the outer surfaces of the ears, and especially towards their tips in winter.

There are quite distinct summer and winter coats, but the underside is at all seasons white; the sharp line of demarcation, on each side, runs from the chin to the axilla, where it forms a V upon the inner surface of the fore-limb, and from the posterior edge of the axilla along the lower edge of the flank to the region of the groin and anus.

In complete **summer** coat the colour of the head, body, and limbs is rich rufous, the crown of the head as well as the posterior portion of the back to a variable extent greyer or browner; the tail is creamy, and thinly haired; there are typically no ear-tufts; and the palms and soles are naked. The hairs are not annulated.

In the **winter** the head and body is brownish-grey or greyish rufous brown; the limbs are rufous, but less so than in summer; the tail is blackish or brownish; the ear-tufts long and brown; the palms and soles hairy. The hairs are annulated.

The above description holds good for a typical South English Squirrel, but the moults are very complicated, and the fur is continually undergoing change resulting in much normal variety, so that it might be found impossible to obtain individuals exactly matching the typical description.

The changes are brought about by two annual **moults** of the body-fur and one only of the long hairs of the ear-tufts and the tail. In addition, the tail and ear-tufts undergo gradual bleaching from the deep brown of winter to the cream or straw colour of summer. This is an undoubted change of colour without replacement of the individual hairs.

The *summer* body coat is coarse and short, reaching a length of about 13 mm. over the rump. It makes its first appearance in the south on about the 20th April, and is completely assumed in the course of about six weeks. A Galway specimen had not started assuming the summer pelage on 3rd June 1896. Starting from the muzzle, fingers, and toe-tips, it spreads backwards and bodywards over the face, hands, and feet, to the neck, flanks, and sides, until it gradually supersedes the old coat, which remains longest on the rump and the backs of the thighs. Notwithstanding this general sequence a patch on the occiput may be latest, and another small patch on the centre of the rump may be the earliest to change. The spring change is remarkable for its "patchy" progress. The summer coat is usually borne until towards the end of October; but a specimen killed at Kilmanock on 20th November 1898 still retained it, the body-fur being thin and reddish, and the tail bleached.

The *winter* body-coat is long and soft, the hairs inconspicuously annulated with brown and dull white, their length about 25 mm. on the rump. It makes its first appearance towards the end of October, and almost immediately starts to bleach, a process continued steadily throughout the winter until the whole animal, with the exception of its rufous limbs, reaches in February or March a uniform dull yellow or drab tint. The spring change to the new coat usually occurs before it can reach the stage of cream colour attained by the tail.

The *tail-hairs* have a cycle running for twelve months from July or August, at which time they make their first appearance as a short blackish covering amongst the roots of their ragged and bleached predecessors. In September, or earlier,[1] they become visible externally, and begin to replace the bleached hairs. Almost immediately after the new growth is completed, they commence to bleach and pass through various shades of brown, pale brown, dull yellowish-brown, until by the following June, July, or August, sometimes even in April, they are almost white. Animals in an intermediate condition present an interesting appearance, in which the tail may be more or less piebald, the middle third of its breadth dusky, with a fringe on each side of ragged, bleached hairs.

Bleaching starts at the tail-tip, which is rarely seen in the full brown condition, and proceeds bodywards. At the same time the hairs gradually wear down or fall out, so that the old tail-coat is thin and poor. The new growth takes place from the body end and reaches the terminal hairs last.

There is no evidence of a regular spring renewal of the tail-hairs. But at least one specimen (mentioned by Thomas), killed on 24th May, shows a growth of new hairs, which, however, may represent a case of very early renewal for autumn, and exactly resembles autumn skins.

The hairs of the *ear-tufts* follow the cycle of those of the tail. They are first noticeable in September, at which time they are dark brown.

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[1] One with the tail in a transitional condition was seen at Kilmanock on 21st July 1895, and another with a white tail at the same place on 22nd December 1893. Specimens with dark tails in August are recorded by Butterfield, *Zoologist*, 1896, 348, and G. W. Smith, *ibid.*, 376.

They continue to grow until January, at which time they have attained a length of about 35 mm. They afterwards become white and thin, and, if they persist after July, are rendered conspicuous by their light colour.

The *palms and soles* are naked from April to November, but during the latter month acquire a coat of short woolly hairs, thicker on the soles than on the palms, which are sometimes more or less unclothed even in winter.

The remarkable cycle of moult and colour-changes indicated above, although considered by Thomas, who first described them in detail (*Zoologist*, 1896, 401), as "both in effect and complexity, quite unparalleled throughout the mammals of the world," had previously been neglected or misunderstood. Blyth[1] probably came nearer to an understanding of them than any other writer, and Macgillivray and Alston (*in Bell*) had a rough notion of a regular sequence, but the majority of naturalists were content to regard the cream or whitish tail as an "accidental variety." Thomas's work was based on the study of a series of Squirrels killed all the year round in a single wood at Whatcombe, near Blandford, Dorsetshire, by Mansell-Pleydell; and although typical enough for British Squirrels generally, Thomas's calendar of the changes must not be regarded as absolutely binding for those taken in other parts of the country. A series procured for Barrett-Hamilton at Saffron Walden, Essex, exhibits a greyer coloration in winter.

Blyth (*loc. cit.*) states that in the case of the young of the first litters the first pelage is that of winter, and this is corroborated by A. H. Macpherson (*Zoologist*, 1886, 67), who twice found young in the nest with bleached tails and ear-tufts, and by Aplin (*Zoologist*, 1885, 479). According to Blyth, the pelage of young of the second litter is that of summer, ear-tufts being absent.

The immature are often redder than are adults. The tails, never rufous in adult *S. leucourus*, are frequently so in young specimens, which thus resemble adult *S. vulgaris* rather than their own parents—a circumstance which, as Thomas remarks, "would tend to show that . . . the British Squirrels were formerly red-tailed when adult."

Eagle Clarke, writing of three males and three females sent from Ballindalloch, Spey, Scotland, on the 3rd March, states that the males were greyer, the females slightly more rufous, especially on the flanks; but there is yet no evidence available indicating that this is the case generally in *S. leucourus*, although Gray (*Ann. Mag. Nat. Hist.*, November 1867, 325) states that this is true of certain South African Squirrels.

Collett (*Norges Pattedyr*, 1911, 217) has proved (from the examination of a long series collected in southern, central, and northern

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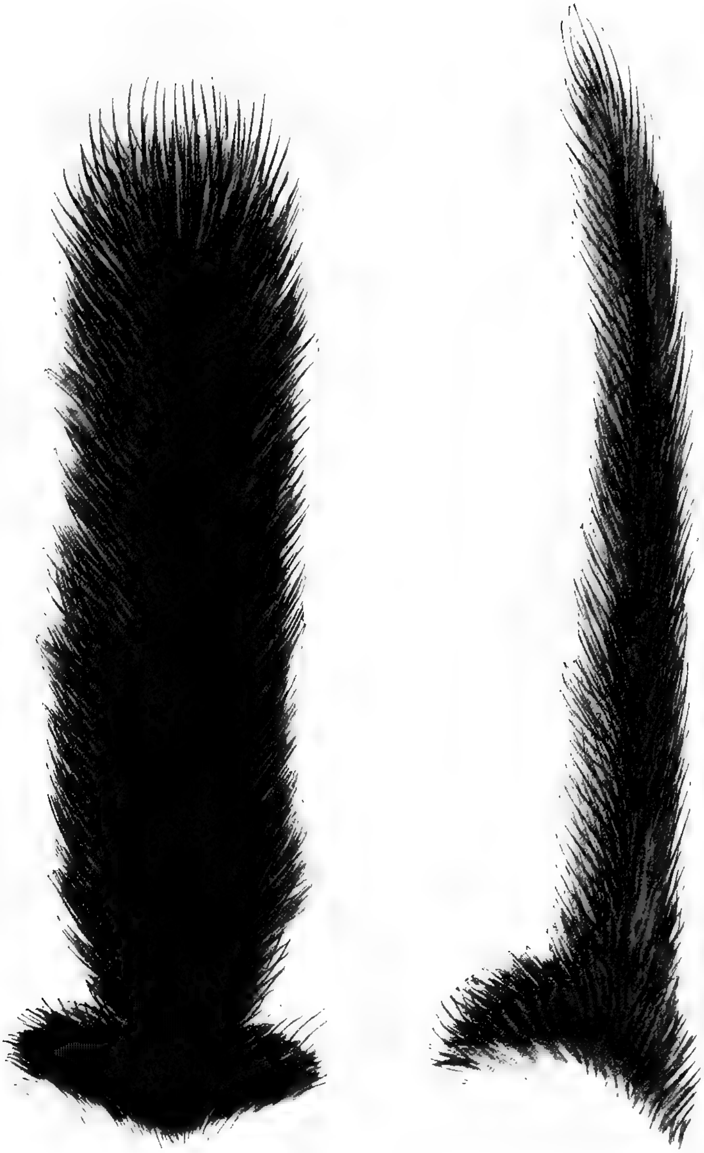
[1] Ed. White's *Selborne*, London, 1836, 280, 281, note.

Norway) that the Norwegian Squirrels (now referred to *S. v. vulgaris* and *v. varius*) have similar moults to those observed in *leucourus*. Thus the body-fur is shed and renewed twice a year—in spring and in autumn; the ear-tufts and tail-hairs only once—in the course of the summer. Though subject to considerable individual variation, the precise moment of change, as in England, appears to depend very little upon weather. At the autumn moult, the first grey hairs appear on the posterior half of the back; then they appear on the upper surface of the thighs and forepart of the back; later they spread over the flanks and fore-limbs; and lastly on the belly and inner sides of the thighs. The spring moult follows a converse order: the belly first becomes thin haired; then the outer sides of the arms become red; next the flanks and inner surfaces of the thighs become yellowish-red; after this the grey hairs fall from the outer sides of the thighs, and lastly from the back, where in the neighbourhood of the rump long pendulous grey hairs can remain until a very advanced date. The colour-changes of the Norwegian animals are produced solely by the replacement of the old hairs by a new growth, and the bleaching process, so characteristic of the British species, is apparently quite unrepresented in them, as well as in the other continental races of *S. vulgaris*.

Bleaching is known to occur also in *Heliosciurus mutabilis*, a species inhabiting Nyasaland (Thomas, *P.Z.S.*, 1894, 140), and in *Ratufa bicolor*, a Giant Squirrel inhabiting Java (Bonhote, *A.M.N.H.*, [7] v. 490). In *leucourus*, as pointed out by Thomas, it "takes place mainly in the winter and early spring, so that it cannot be assigned to the special action of the summer sun." Further, it affects only the annulated hairs with blackish-brown pigments, and not the unannulated hairs with rufous pigment; thus in "February and March skins, the whole animal, from nose to tip of tail (but not the rufous limbs), is bleached to one uniform dull yellowish or drab tint" (Thomas, *Zoologist*, 1896, 406). It seems probable from these facts that there is an important difference in the chemical constitution of the red as opposed to the blackish-brown pigment; the bleaching of the latter appears to be a process strictly comparable with that which we have described as taking place in the hairs of the House Mouse (*antea*, p. 643).

It is of interest to note in conclusion that Collett (*op. cit.*, 220) has described two distinct pelages of the young Norwegian Squirrels. According to him, nestlings first develop a red coat in which there is usually a more or less strong intermixture of whitish-grey hair, especially noticeable on the head and flanks. In this pelage, especially in Northern Norway (Finmarken), the grey tone may be as strongly evident as in the winter coat of many adults. This "nestling" pelage is changed apparently wholly or in part when the young are half grown, and it is succeeded by the true juvenal pelage, which is quite red. The



THE BRITISH SQUIRREL—*Sciurus leucourus.*

TAIL (half life size), showing normal flattening—(*a*) dorsal view ; (*b*) lateral view.

latter is borne until the autumn, when it is changed for the normal first adult winter pelage, the moment of change, however, being frequently later than in adults. The nestling pelage of Collett may perhaps be compared with that described by Blyth and others, noticed above, but it is to be hoped that some favourably situated observer will give further information concerning the first pelage of *S. leucourus;* at present we have little material bearing upon this matter.[1]

Variation:—Thomas's Dorset series may be regarded as typical. Squirrels from colder parts of the country are greyer in winter, with a darker, browner central dorsal line, and in summer redder flanks. An extreme example of this type was taken near Bury St Edmunds, Suffolk, in very cold weather on the 2nd February.

S. leucourus, being confined to Britain, has no definite **geographical variation**, such as is exhibited in a very beautiful manner by its closely allied representative, *S. vulgaris*, on the continent of Europe.

Exceptional variation runs mainly towards albinism; melanism, although extremely common in some of the sub-species of *S. vulgaris*, being almost unknown. Of the latter variation, records of only three instances, and no detailed descriptions, are available (see Pryor, *Zoologist*, 1865, 9431; Denham, *Field*, 24th April 1909, 721). Records of albinos will be found as follows:—(1) male, pink-eyed, Dack, *Field*, 5th December 1885, 785; (2) large white saddle on back, feet, nose, and three parts of tail white, pink-eyed, Dack, *Field*, 3rd November 1888, 653; (3) Laws, *Field*, 14th December 1889, 862; (4) female, pink-eyed, Matthews, *Zoologist*, 1892, 20; (5) Rushen, *Field*, 24th June 1893, 944; (6) male, pink-eyed, Marsden, *Zoologist*, 1893, 426; (7) female, pink-eyed, *Auct. et Journ. cit.*, 457; (8) pink-eyed, Grabham, *Zoologist*, 1899, 132; (9) pink-eyed, Monckton, *Field*, 28th January 1905, 152; (10) one, white (figured), Brown, *Field*, 8th January 1910, 74.[2] A white Squirrel was killed near

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[1] W. Evans (Supplement, *Proc. Roy. Phys. Soc. Edinburgh*, 16, 1906, 398, and *in lit.* to Barrett-Hamilton) has described young, three to ten days old, from two nests in the Edinburgh district. In one case, examined 21st April 1904, the three still blind nestlings "seemed to be rather less than 3½ inches in length, exclusive of tail, which might be fully 2½ inches, and showed no tendency to curl upwards over the back. They were covered on the upper surface with very short silky hair of a rich chestnut or rufous colour; skin on upper parts of legs and about the eyes bluish; under surface yellowish-white; tail straight and clothed with short blackish hairs." The other nest, found 4th May 1904, contained "three young ones, naked and blind and not more than three or four days old." Evans figures one of these babies, which he sent to Barrett-Hamilton; he says: "Its length was 75 mm. excluding the tail, which measured 40 mm.; colour, dark bluish-grey."

[2] Cocks put "three young squirrels to a domestic cat, and eventually sent them to the Zoo, where one soon died, but the other two were reared. These turned *white*, but whether because they were albinos, or in consequence of the influence of the cat's milk, or the absence of sunlight from the keeper's room in the small mammal house at the Zoo, cannot be said."

Gorebridge, Midlothian, in January 1908 (W. Evans, *MS.*). Of particoloured specimens the following are remarkable: one, having the moustache, nose, upper lips, forefeet, two joints of the hind toes, and the claws white, with, in addition, on each side a band of white, an inch broad, proceeding from the white of the belly, and nearly meeting its fellow dorsally; a similar band, about 2 inches broad, towards the tip of the tail was arched over the back (Bold, *Zoologist*, 1848, 195). The latter seems to have been somewhat similar to one in the collection of J. W. Whitaker, of which he kindly sent us a sketch; this specimen was shot in Nottinghamshire, and has a broad transverse band of white, only narrowly interrupted dorsally, around the middle of the body, the nose, fore-limbs, and distal half of the tail being also white. A third specimen of somewhat similar appearance was noticed in the *Field* of 3rd November 1888, 653 (C. B. Dack).

Skull:—The **skull** is broad, smooth, and rounded, with a short, narrow, but deep rostrum, and a large, broadly ovate and deep brain-case. In dorsal profile the nasals are slightly, and the fronto-parietal region very, boldly convex; the line is slightly concave between the orbits, and again just in front of the occiput; these concavities mark the positions of the internal divisions between the cerebral part of the brain-case and the olfactory and cerebellar fossæ respectively. The occiput is vertical or slightly overhanging, the condyles being hidden in the dorsal view, and owing to the backward deflection of the cranial axis the foramen magnum lies wholly below the level of the alveolar line. The nasals are short and broad, widest and well arched in front; their tips end well in advance of the incisors; posteriorly their ends lie a little in front of the very broad ends of the ascending branches of the premaxillæ. The frontals have large superciliary processes, which partly roof the orbit and terminate behind in long, slender, postorbital processes, directed backwards, outwards, and downwards. From the hinder edge of each of these processes a feebly indicated temporal line passes backwards to blend with the weak lambdoid crest; the fronto-parietal area between the two temporal lines is lyre-shaped. The interparietal is small and distinct in young skulls, but in adults it is completely fused with the parietals. The very small infraorbital foramen on each side is placed considerably in front of the cheek-teeth, and its lower edge forms a conspicuous little process of the maxilla for the attachment of the tendon of the masseter. The anterior root of each zygomatic arch is a stout plate, homologous with the "masseteric plate" of the murine skull; the ridge which forms its upper boundary and marks the limits of the origin of the *masseter lateralis* muscle is continued forwards for some considerable distance upon the side of the premaxilla. The large jugals form distinct though low postorbital crests; posteriorly they articulate by means of a long scale-like suture with the squamosals, anteriorly with the zygomatic plates of the maxillæ and with the small lachrymals. The greatest zygomatic breadth falls slightly in front of the glenoid regions. The anterior palatal foramina are very short and narrow; they barely notch the maxillæ. The palate is broad and flat, or rather slightly concave, with a more or less evident trace of the median suture; the maxillo-palatine suture extends forwards to the level of m^2; the posterior palatine foramina are very small; the palatines extend for 2 or 3 mm. behind m^3, each having a well-marked circular notch on its margin behind that tooth. The mesopterygoid fossa is wide, and squarely truncated in front; the pterygoid bones are small and thin, their hamular processes considerably in front of the bullæ; the ectopterygoid processes are feeble ridges, and behind each is a very large *foramen ovale.* The presphenoid and basisphenoid are wide and little modified. The ventral surface of the broad basi-occipital has the median ridge and lateral concavities little developed, but its margins are raised as conspicuous little flanges which are applied to the inner surfaces of the bullæ. The paroccipital processes are small, short, and stout, terminating above the level of the condyles. The bullæ are small, round, and moderately inflated; internally they are divided by a number of bony septa; the external meatus of each shows the beginning of a funnel-shaped prolongation; the petrous portions are of moderate size.

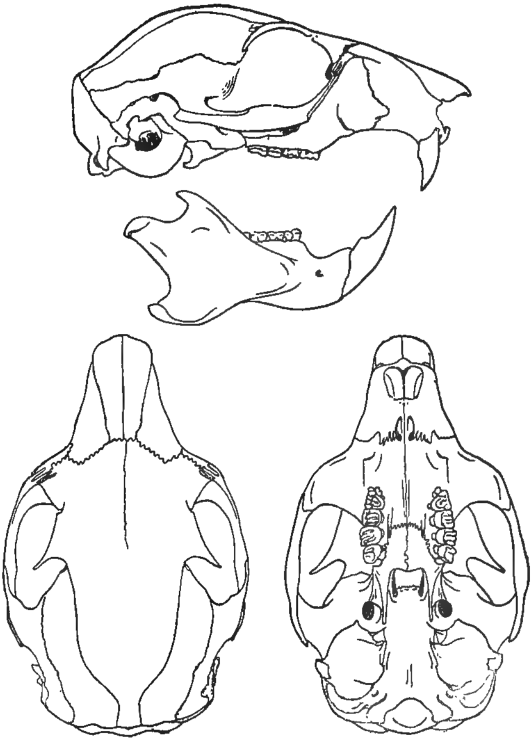

FIG. 99.—SKULL OF SQUIRREL (*Sciurus vulgaris*). Life size.

The **mandible** is laterally compressed, and in relation to the molars deep and heavily built. The lower incisors pass upwards close behind m_3 to terminate in the bases of the coronoid processes. The condylar and angular processes are stout; the coronoid processes are rather slender and recurved, but they rise noticeably above the level of the condyle.

The **dentition** has been described above under the genus, p. 686.

DIMENSIONS IN MILLIMETRES:—

	Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (without tufts)	Weight in grammes.		Head and body.	Tail (without hairs).	Hind foot (without claws).	Ear (without tufts).	Weight in grammes.
SCIURUS LEUCOURUS.											
1. SPECIMENS FROM WHATCOMBE, BLANDFORD, DORSET (B. M. serial, No. 97, 1-16).											
MALES:—						FEMALES:—					
1. 21st Jan. 1895	205	185	55	30	..	1. 21st Jan. 1895	216	162	59	28	..
2. ,, ,, .	222	169	56	27	..	2. 18th April .	213	166	55	27	..
3. 9th May .	211	169	59	27	.	3. 2nd May .	207	187	59	29	..
4. ,, ,, .	209	178	56	29	..	4. ,, ,, .	192	172	55	28	..
5. 24th ,,	200	139	56	29	..	5. 24th ,, .	219	176	56	35	..
6. 15th Aug. .	202	176	56	28	..	6. 13th Sept. 1894	216	170	59	29	..
7. 17th ,, .	196	155	53	27	..	7. 30th ,, 1895	213	170	55	28	..
8. 19th ,, .	202	184	58	28	..	8. ,, ,, .	193	158	55	18	..
9. 30th ,, .	205	165	56	28	..	9. 24th Oct. .	210	175	55	27	..
10. 13th Sept. .	196	160	52	27	..	10. 29th ,, .	216	172	58	29	..
11. 9th Oct. .	195	149	55	27	..	11. ,, ,, .	202	185	57	29	..
12. 15th Dec. 1894	216	182	57	28	..	12. 6th Nov. 1894.	215	171	55	28	..
Average of 16 males in adult pelage (including the above) . .	205	169	55	28	..	Average of 35 females in adult pelage (including the above) . .	207	172	56	28	..
2. SPECIMENS FROM SAFFRON WALDEN, ESSEX.											
13. 25th Sept. 1896	201	174	54	..	..	13. 1st Oct. 1895 .	198	166	55	..	..
14. 2nd Nov. 1895	218	170	62	..	..	14. 30th Sept. 1894	218	170	53	..	227
15 26th Oct. .	220	174	58	..	..	15. 30th Mar. 1895	220	172	54	..	.
16. 2nd Nov. .	220	163	59	..	..	16. ,, ,, .	228	177	55	..	..
17. 29th Aug. 1896	225	164	55	..	..	17. 4th July 1894 .	232	166	57	..	..
18. 27th Feb. 1895	238	188	58	..	..	18. 15th Dec. 1894	234	172	57	..	..
19. 27th Ap. 1894 .	243	168	56	..	340	19. 20th June .	238	175	57	..	..
Average of 21 males in adult pelage (including the above) . .	220	170	56	..	..	Average of 21 females in adult pelage (including the above) . .	217	171	54	..	..
3. SPECIMENS FROM SCOTLAND.											
1. Ballindalloch, Spey, 3rd March 1892 (W. Eagle Clarke), male . .							237	170	63	35	334
2. ,, ,, ,, ,, . .							229	165	59	33	278
3. ,, ,, ,, ,, . .							..	..	.	..	336
4. ,, ,, ,, female . .							213	162	56	31	330
5. ,, ,, ,, ,, . .							221	167	61	33	340
6. ,, ,, ,, ,, . .							213	178	58	31	253
7. Nethybridge, Inverness-shire, 14th-17th March 1913 (C. H. B. Grant and D. Anderson), male							210	170	56	31	..
8. ,, ,, ,, ,, ,, female							205	171	55	30	..
9. ,, ,, ,, ,, ,, ,,							208	181	57	29	..
10. ,, ,, ,, ,, ,, ,,							218	171	55	30	..
11. ,, ,, ,, ,, ,, ,,							219	176	56	27	..
12. Blackwood, Lanarkshire, 24th Sept. 1904 (N. B. Kinnear), female .							208	168	55	29	312

Remarks :—All the specimens dealt with in the foregoing tables were in adult pelage; the individuals enumerated include the largest and the smallest specimens of each sex in each of the long series examined from Blandford and Saffron Walden. Macgillivray states that the female is smaller than the male; to some extent this statement is supported by the above figures, although the difference is small; the largest males appear to exceed by 5 mm. the largest females as regards the length of the head and body.

Weight:—Four from Saffron Walden were weighed, viz., a male and a female (Nos. 19 and 14 respectively of the above table) of 12 and 8 oz., or 340 and 227 grammes respectively; and two males, one taken on 26th April (head and body, 235) of 10 oz. or 283 grammes, the other killed on 30th September (head and body, 227) of 9 oz. or 255 grammes. A male from Upware, Cambridgeshire, taken on 24th August (head and body, 224) weighed 8¾ oz. or 248 grammes. Three males, killed 26/27 December, from Co. Wexford (lengths unrecorded), weighed 10, 10½, and 11¼ oz., or 283, 298, and 319 grammes respectively. The heaviest, of which we have a record, was a male from Ringwood, which reached 17 oz. or 482 grammes (Corbin, *Zoologist*, 1886, 178).

Skull:—Condylo-basal length, 44 to 48: breadths—zygomatic, 29 to 31·6; mastoid, 21 to 22·2; least postorbital, 17 to 18·2; least interorbital, 16 to 18; anterior rostral, 7 to 8·8: lengths—of nasals, 13·8 to 15·8; of diastema, 11 to 13; of maxillary tooth-row, 8·8 to 9·6; of mandible, 30 to 33·6; of mandibular tooth-row, 8·4 to 9·4.

The form and habits of this elegant little creature combine to render it one of the most beautiful and entertaining of our native mammals. Dwelling principally upon trees, but frequently descending to the ground, it leaps from bough to bough with astonishing agility; but should it miss its mark it usually alights safely like a cat, and runs away little the worse for a fall from even a considerable height.[1]

Though bold and easily observed, it is subject to fits of panic, and exhibits a somewhat contradictory character. Thus, although not hesitating to descend to the ground and roam for a considerable distance from trees, it will, on the slightest alarm, race in a series of long bounds for its leafy refuge. With the utmost circumspection it carefully climbs the tree-trunk, on the side away from its enemy; but then, perhaps thinking itself secure and possibly overcome with indignation or curiosity, it usually emerges into full view, often within easy gunshot, and, neglecting to make good its escape, sits chattering, swearing, and stamping its feet, a charming picture of fuss and impudence. On such occasions, as Sir H. Johnston observes, its voice is capable of considerable variation, ranging from a series of metallic "clacks" to a rapid succession of spitting squeaks.

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[1] See Editor, *Field*, 24th September 1893, 473; on the other hand, W. H. Scott, *ibid.*, 1900 (95), 771, records the death of one from a fall.

Much of the Squirrel's characteristic appearance is due to its tail, an appendage with a great variety of uses and playing the chief part in almost every incident in its owner's career. In climbing, running, swimming, or leaping, the tail is directed straight backwards, serving as a balancer, rudder, or combined with the horizontally spread limbs and the distended loose integument of the flanks as a parachute. In sleep it covers and warms the whole lateral and dorsal portions of the body. When the animal is more or less quiescent the tail is bent abruptly forwards along the back towards the head, the tip slightly recurved outwards. At such times the various emotions are expressed apparently by a series of jerks of the tail, which may perform the part of a banner of defiance, or a lure to a genuine or sportive adversary. To enable it to play its varied roles, the tail possesses extraordinary mobility, and is provided with special muscles whereby the arrangement of the hairs may be suited to fit each passing mood. The hairs may at will be horizontally flattened for purposes of balance, or each hair may stick out directly from the central support, so that the outline of the tail is circular like the plume of a hussar's busby. The latter shape is affected especially when another Squirrel is the subject of sport or defiance; the hairy tail is literally thrust into the mouth of the adversary, and is used as an invulnerable hairy vanguard to excite and confuse the enemy.

The Squirrel has little fear of the proximity of man; it often enters the pleasure-grounds of large towns, and indeed frequently courts the vicinity of houses, being, doubtless, attracted by the produce of their gardens; of diurnal habits, it is frequently visible, in such circumstances, from the windows of houses surrounded by woods. If fed and encouraged—and nothing, from bread to a chicken-bone, comes amiss to it—it sometimes becomes very familiar, and soon learns to enter by the windows to secure an accustomed meal. Even perfectly wild Squirrels have been known to climb or enter a house, either to escape danger, to rob a sparrow's nest of the young birds, or even, in hard weather, to steal bread.

Its food is very varied, and includes almost every vegetable substance from which nourishment can be extracted. In text-books the nuts of the hazel usually appear first in its dietary; but, if the truth be told, they are probably eaten much more rarely than are many other more easily obtainable substances, such as leaf-buds and tender shoots, young bark, acorns, beech-mast, seeds of sycamore, fir-cones and haws, all of which are included in every comprehensive list. It also feeds largely on fungi (agarics, etc.) in the autumn (W. Evans). Mr O. V. Aplin[1] has described the actions of a pair of Squirrels as they gathered beech-mast and carried it away to their winter retreat in some thick firs. He says:—"As the mast grows at the extreme outside of the trees, and only at the end of the slender drooping twigs, and usually out of (Squirrel) reach of any of the thicker branches, I imagined they had to content themselves with any of the fallen nuts. But I found that they ventured boldly out into the small twigs, and, hanging on by their hind legs, drew the mast to them by their forepaws and bit it off, when, with the exercise of the greatest agility, they twisted round, and with a quick jump regained the stronger branches. Of course, a good deal of the mast fell to the ground, and Squirrels seemed occasionally to get quite out of temper with a refractory twig which refused to come to hand; when this happened, the angry impatient snatches made by the little animals were quite amusing. No doubt they felt their position precarious, for the breaking of a twig or the slip of a claw meant a clear twenty-foot drop, with nothing to catch at: no great matter, of course, to a Squirrel when it throws itself off a bough to drop, parachute-like, to the ground, but quite another thing when taken as an unexpected fall."

Whenever opportunity offers, it leaves the woods in search of fruit, pilfering plums, Spanish chestnuts, cherries, apricots, peaches, strawberries, pears, and bilberries. As a rule it eats only the soft parts, but sometimes the kernels are devoured. There can be no doubt that, when numerous, apart from its depredations in gardens, it often causes serious damage to plantations; and, although the lover of nature may agree with Sir H. Johnston, that its misdeeds are partially atoned for by its fascinating appearance, the prudent forester will keep its numbers from assuming inconvenient proportions. One of the most conspicuous of its misdemeanours is its habit of attacking the early leaf-shoots of the horse chestnut, or less frequently of sycamores, which in spring appear to be very palatable to it, and are ruthlessly torn from the tree and then thrown to the ground. It is no less destructive to the young shoots and leaves of the beech. Alston accused it of barking young birches,[1] and a number of authorities have shown that amongst its gravest offences is the stripping off of whole areas of bark right round a tree trunk, especially a conifer, at a distance of a few feet of the top—thus damaging the leading shoots. This it does to get at the inner bark. The resulting damage is incurable in the case of conifers, the tops of which decay and then turn over before the wind. Such crimes chiefly occur in the new woods of replanted areas, and are most often seen in trees of about twenty years' growth. Younger trees appear to be exempt, as do also the older firs of native forests, in which the more abundant cones supply a quantity of food.

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[1] *Zoologist*, 1885, 478.

The loss from such attacks has been estimated at very high figures in Scotch forests. At Glen Tanar, Aberdeenshire, one thousand trees worth £500 were ruined in one year; and on the Cawdor Estates it was considered worth while to pay over £200 for the destruction of more than fourteen thousand Squirrels between the years 1862 and 1878.

But there is another count on which the Squirrel must meet with our righteous condemnation, namely, for its destruction of the eggs and young of birds, concerning which the testimony of many accusers is, despite a vigorous defence by the many admirers of the culprit, now unquestionable. Thus Captain Saville G. Reid charges it with robbing the nests of the Long-eared Owl, and, on one occasion, of the Greater Spotted

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[1] Cocks finds young crabs (while still in more or less bush form, before they become single stemmed trees), barked throughout at Poynetts.

Woodpecker. The Rev. A. Ellison finds that in Ireland it is one of the worst enemies of small birds, of which it devours both eggs and young. Indeed, once the bird-nesting habit has been acquired—for it must be admitted that it does not manifest itself universally in the species—eggs, fledgelings, or, if they can be surprised, even adult birds are all acceptable;[1] and one has even been discovered in the act of carrying off a small chicken from a poultry yard. It is a clumsy robber, and its handiwork may be recognised by the portions of its repast left behind or scattered about the raided nest. Captain Reid protected a Woodpecker's nest from further disturbance by smearing a ring of tar around the trunk.

The Squirrel is not content to restrict itself to such provender as is provided by woods. All through the year it may be seen, either in search of food or of nesting materials, grubbing assiduously on the ground, often at a little distance from trees. At such times it is very active, working hard and spending much time at its exercise. From time to time it desists from its exertions either to survey its surroundings or to drive away a comrade—the pursuit being often hot enough to include much doubling and winding, and perhaps a chase up a tree. Frequently also it sits bolt upright, the tail lying at right angles along the ground evidently as a support, and, holding some dainty in its paws, nibbles and eats; but if the object of its attentions be of comparatively large, although portable size, it usually retires with its booty up a tree, as when Mr W. Evans found one carrying a mutton bone fully 7 inches long. Its gait is not a walk or a run, but a series of short leaps, the fore and hind limbs working together in pairs. On its terrestrial expeditions it has been found to devour plantains, daffodils, crocuses (the whole plant), tubers of the lesser celandine, Indian corn and ants' eggs. It

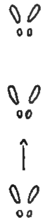

FIG. 100.—SPOOR OF SQUIRREL IN SNOW.

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[1] Cocks says (*in lit.*):—"There are some spruce firs near the house here [Poynetts], always utilised by sparrows for nesting, 25 to 30 feet up, but for several years now not a single young bird has flown, all the nests being regularly raided by squirrels. They destroyed a nest-box in a Scotch Fir adjoining these. If they thus take *every* sparrow from this particular *scattered* lot of spruces they must do serious damage to other small birds of more value."

is also fond of several kinds of fungi, including mushrooms, and will tear off old bark of trees in search of them. Von Tschudi long ago declared that the Alpine Squirrels dig up truffles, and this observation was repeated for Britain at Elveden, Suffolk, by the late Prof. A. Newton and one of his brothers, and in Ireland by Mr P. Bicknell.

In eating, the Squirrel holds its food to its mouth with its fore-paws. In gnawing through the hard shells of nuts it displays much skill. Captives observed by Mr Bonhote always held a nut by the larger end and nibbled a hole into the smaller end; when the hole was large enough, they inserted their lower incisors, and with a sharp jerk of the head a piece of the shell was broken off, an action repeated until the kernel could be extracted. The scales of fir-cones are bitten off, and the seeds devoured; the presence of fossil fir-cones in the late pliocene Forest Bed of Norfolk gnawed in this way has been mentioned above (p. 695).

Sometimes the terrestrial foraging expeditions are carried far afield, as must needs be the case when it journeys from one wood or plantation to another, and Barrett-Hamilton knew one to be caught in a trap set for rats in a field of cabbage. It has been frequently encountered amongst the heather of the Scotch moors, and a number of instances of such wanderings were collected by Mr Harvie-Brown while compiling his paper on the Squirrel in Great Britain. From these it appears that single Squirrels have strayed for distances of at least 9 miles from the nearest trees, so that it is not surprising to find that newly wooded districts are rarely long neglected by this species, as has so frequently been shown in Scotland, Wales, and Ireland. Sometimes wandering Squirrels find themselves in very unexpected quarters, as after entering houses by their chimneys. The most remarkable escapade is that related by Mr A. E. Knox of a Highlander, who, never having seen a Squirrel before, came across one on an open moor. It is doubtful whether man or Squirrel was the more surprised: the latter, to avoid the Highlander's dog, promptly climbed to the top of the man's head; the Highlander, greatly alarmed, believed his assailant to be "a thing wi' horns." It appears that roads, walls, rails, or hedgerows, and even railway bridges have much influence upon the wanderings of the Squirrel since it loves to follow anything straight.

Even when it meets water it is not always nonplussed, for, although the larger Scotch rivers, until bridged, are said to have proved effectual barriers to its repopulation of that country, it has undoubtedly the ability to cross wide streams. The Squirrel has been figured while swimming by Mr Millais. It swims high, the tail flat on the water. Amongst the most conspicuous instances of its activity in this direction may be counted the discovery of one crossing Loch Toil where its breadth reaches one-third of a mile, by a lady correspondent of Colonel H. H. Godwin-Austin; while another was seen to cross the River Spey, where the stream is broad, strong, and deep; and Mr Meade-Waldo saw one swim across Loch Ericht at a place where the loch was one mile wide—when this Squirrel landed its tail was perfectly dry.

The Squirrel has been credited by most writers with provident sagacity in laying up stores of food for the proverbial rainy day. "I have a venturous fairy," says Titania, "that shall seek the Squirrel's hoards and fetch thee new nuts." The distribution of these reserves, not in a single place of safety, but in several holes in different trees in the neighbourhood of its retreat, has been often regarded as further evidence of forethought; but, if the truth be told, the Squirrel is but a careless housekeeper at any time, and no more worthy of praise in this respect than the well-fed dog which spends its spare time in burying the bones which it is unable to consume. The erratic nature of the Squirrel's stores was long ago commented upon by Alston, who watched the storing operations of a semi-tame individual. This Squirrel, when fed with nuts out of doors, hid them in a most capricious manner in soft turf, not taking them all to one place, but burying them anywhere at random, so that "one could hardly believe he would ever find them again; and I have no doubt that he never did find some of them."

The habit of storing surplus food, be it intentional or the result of blind energy, is present, as in so many other rodents; and there can be no doubt that, although of comparatively little importance in this country, in severer climates than that of Britain it must be a necessary action, failure to perform which may result in the death of the defaulter. In North America Dr Merriam states that the Red Squirrel (*S. hudsonicus*) makes larger stores and fares better in winter than the Grey Squirrel (*S. carolinensis*).

It seems more than probable that many of the older myths which gathered around the Squirrel's "treasured hoards" owed their prevalence to the still more erroneous belief that the animal remains during the greater part of the winter in a state of almost complete torpidity, from which it only relapses on fine days for the purpose of feeding. As a matter of fact, the Squirrel is quite active throughout the winter and in all degrees of cold. This fact is none the less compatible with a strong dislike of snow or rain, during the prevalence of either of which it may remain in its nest for several days together. Notwithstanding any such prejudices, however, it is often to be observed abroad in all kinds of weather, and Mr Hewitson remarks that its footsteps are the first to soil the unsullied beauty of the snow. He records an extreme case in which young Squirrels, little more than able to leave the nest, were running about on snow in March.

Some of the most interesting or striking myths deserve mention. Pennant and Bingley relate of it that its gullet is very narrow, "to prevent it from disgorging its food, in descending of trees, or in down-leaps." Topsell, repeating an ancient and widespread legend, the details of which, according to Mr Harvie-Brown, are still related as actual facts of natural history in Scotland, says:—"If they (*i.e.* Squirrels) be driven to the ground from the trees to creep into hedges, it is a token of their weariness, for such is the stately mind of this little beast, that while her limbs and strength lasteth, she tarryeth and saveth herself in the tops of tall trees, then being descended, she falleth into the mouth of every cur. The admirable wit of this beast appeareth in her swimming or passing over the waters, for when hunger or some convenient prey of meat constraineth her to pass over a river, she seeketh out some rinde or small bark of a tree, which she setteth upon the water, and then goeth into it, and holding up her tail like a sail, letteth the wind drive her to the other side; and this is witnessed by Olau Magnus in his description of Scandinavia, where this is ordinary among squirrels by reason of many rivers, that otherwise they cannot pass over, also they carry meat in their mouth to prevent famine whatsoever befal them, and as peacockes cover themselves with their tails in hot summer, from the rage of the sun as under a shadow, with the same disposition doth the squirrel cover her body against heat and cold."

Mr E. H. Cuming quotes the old writer, Lovell, that the tail "serveth them as a wing in leaping. They obscure themselves with it in trees and use it as a sail in the water, swimming upon a bark." In Skandinavia, according to Alston, it bears the character of a tale-bearer, for ever and anon it runs up and down the sacred ash tree, *Ygdrasil*, which supports the world, spreading discord between the eagle seated on the boughs and the great snake, *Midgårdsörmen*, which lies in the abyss beneath. It is not unlikely that this belief may have something to do with the practice of the German peasants who hunt it at Easter, and of the English who hunted it at Christmas. Simroth attributes these practices to "Christian hatred of the darlings of the heathen gods." Apparently the chase did not always result in harm to the Squirrels, since Mr Briggs writes of Duffield, Derbyshire, where Squirrel hunts were customary on Mondays, that after the capture of several they were taken back to the village, released, and the hunt renewed. The plan of campaign was to make such an uproar with the blowing of horns and other instruments that the frightened creatures eventually dropped off the trees and were taken. But the Squirrel is not always so resourceless, a hunted one having been observed, there being no tree available, to take refuge in a heap of stones. Mr W. Evans has, on several occasions, seen it going to ground in a rabbit burrow when hotly pursued, and it has even been dug out like a fox.

Organised hunts could hardly have been common until after the destruction of the forests in the Middle Ages, when the woods had become thinner, and the old rhyme prevalent in one form or another in many localities was no longer true—

"From Blacon Point to Hilbree
A Squirrel may jump from tree to tree."

The Squirrel loves comfort, and prepares for its sleeping-place a capacious nest or "drey" built high amongst the branches of a tree—in Scotland very often a fir of some kind, according to Mr W. Evans—or hidden inside a hollow trunk.[1] This is constructed in a very beautiful and intricate manner of moss, leaves, and fibres curiously interleaved. It is lined with dry grass or wool[2] if available, and looks like an immense wren's nest. Usually a definite entrance is wanting, the sides being elastic and self-closing after the inmate has passed through. At all times, even if present, the orifice is hard to find—a fact which probably induced Pliny's remark that the owner closes its retreat on the side from which the wind is likely to blow and opens it on the opposite direction.[3]

The Squirrel is sometimes a sound sleeper, and may, on occasion, be caught napping. Since its presence inside the drey cannot be detected until the touch of the birdnester's hand arouses it, its sudden exit is often not a little disconcerting to a climber balanced at some considerable altitude in a precarious position.

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[1] Probably climate and season have something to do with the site of the nest. In the cold regions of North America, Squirrel nests are invariably concealed in holes in trees, or even in the ground, while in the more temperate regions they are built in branches of trees, like the nests of crows (Merriam, *Mamm. Adirondacks*, *Trans. Linn. Soc. New York*, ii., 1884, 132).

[2] Squirrels were seen by Hodgson collecting sheep's wool for this purpose from a thorn hedge (*Trans. Cumberland and Westmorland Assoc.*, 1885-86, 30). Mr W. Evans (*in lit.*, 23rd March 1910) has given us detailed information as to the structure of three breeding nests examined by him. One (at Clubbiedean, Pentlands, 23rd March 1896) was "profusely lined with sheep's wool, etc., but no young in it yet." Another (near Edinburgh, 21st April 1904, with three young) had a "foundation of twigs, then moss outwardly, and lined with profusion of sheep's wool and rabbits' fur; green leafy fir twigs were placed on top of nest." The third (near Edinburgh, 4th May 1904, with three small blind young) was "made outwardly of moss, then shreds of inner bark of lime, followed by a dense matted lining of rabbits' fur, mixed with bits of fibre and some feathers of pheasant and wood-pigeon; thatched with fresh spruce twigs; approximate diameters: horizontal, 10 inches; vertical, 13 inches; circumference about 35 inches." Mr Moffatt saw one "freshly lined with squirrel's fur and covered with fresh moss"; and Mr C. E. Wright of Kettering found a nest in a hole in a tree "lined with a little fur on leaves."

[3] The ancients held a similar belief regarding the hedgehog: this is mentioned by Aristotle (*Hist. Anim.*, D'A. W. Thompson's ed., 1910, ix., 6, 612 b, 4), Plutarch (*Soll. Anim.*, 979 A), and in Pliny (viii., 56): "In regard to the instinct of hedgehogs, it has been observed in many places that, when the wind is shifting from north to south, and from south to north, they shift the outlook of their earth-holes, and those that are kept in domestication shift over from one wall to the other (Plutarch). The story is that a man in Byzantium got into high repute for foretelling a change of weather, all owing to his having noticed this habit of the hedgehog."

Occasionally Squirrel's nests are reported from curious situations, as when the Rev. J. G. Tuck found one in a loophole of the church tower of Tostock, Suffolk. Its foundation was an old sparrow's nest, to which a quantity of dry grass had been added. A second remarkable nest, of which Mr Forrest sent Barrett-Hamilton an account, was placed in a straggling gorse bush at a height of not more than 4 feet from the ground. Sometimes an old magpie's nest may be put into repair by the Squirrel, which probably has to renovate its drey every season, although the dreys are built of a strength sufficient to last for years. An impossible situation sometimes ascribed is a woodpecker's hole in a tree trunk, but clearly such a hole would be too small to admit the body of a Squirrel.

Mr W. Evans says: "Clean and trim as it appears to be, the Squirrel, like the Hedgehog and the Mole, is greatly infested by a flea, the species in this instance being *Ceratophyllus sciurorum*, Bouché, which is invariably present, and usually in abundance, both in the nests and on the animals themselves."[1]

Every Squirrel is supposed to possess two or three dreys, and one of these is no doubt strengthened and repaired for the reception of the young. According to Edward Jesse,[2] the prospective mother begins by gathering mouthfuls of dry benty grass, of which she makes a considerable deposit. Just before the young are born, she scratches or pulls the fur off her stomach, and thus makes them a warm lining.

The number of young varies from one to six,[3] and the average of twenty litters, recorded in Barrett-Hamilton's notes, from many parts of the British Islands is three. Two litters each summer would appear to be quite usual in the south (though not in Scotland), but the young are most often found in the nests in March and April. Earlier instances are, however, available, as when young nearly as large as rats were found in the second week of February;[1] these must have been born in January. Mr Forrest also mentions the finding of three dead young at the foot of a tree in the latter month. Later litters are found throughout May, June, and into July, but the latest of which Barrett-Hamilton had personal knowledge was on 14th August 1891, when he saw "two quite small young ones, the eyes unopened, which had fallen from their nest in County Wexford."

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[1] W. Evans, Supplement, *Proc. Roy. Phys. Soc. Edinburgh*, 1906, 400.

[2] *Gleanings of Nat. Hist.*, 1842, 214.

[3] One litter of six from Ashburnham Park, Sussex, 15th April 1895, *fide* N. F. Ticehurst. Mr Oldham (*in lit.*) mentions a drey with five young, observed by him near Droitwich on 31st August 1918; above the drey three young, belonging to an earlier litter, were clinging to the tree trunk.

In early spring an energetic courtship takes place; as usually observed, this consists chiefly of the strenuous pursuit of a coy female by several ardent males. According to Blasius, the males of the nearly allied continental species sometimes fight fiercely with each other for the possession of the females; but we are not aware that this habit has ever been observed in British Squirrels, although males are often far more numerous than females. We have no definite information as to the length of the period of gestation, the Squirrel usually being sterile in captivity; Collett states that Norwegian Squirrels go pregnant for four or five weeks. Lataste was not able to determine whether the ovarian cycle lasted ten days, as in many other rodents, or not; he thought those of Southern Europe to be polyœstrous. On the other hand Heape regards the British Squirrel as probably monœstrous.

The young at birth are blind and naked, with long, straight tails and well-developed claws on their hands and feet. One, not more than three or four days old, has been figured, from a photograph, by Mr W. Evans (as mentioned above, p. 701). They grow rapidly, and leave the nest after they are a few weeks old. The parents are said to be monogamous, and their offspring, according to some writers, remain with them until the following pairing season, the young of two litters even uniting to follow their mother. We doubt the truth of this story, however, and prefer to believe that the experience of Mr Hodgson, who saw the father and mother combining to drive away their young, is more usual.

Although, perhaps, not too careful a mother, the female will guard her young jealously while they are still in the nest,

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[1] *Field*, 6th March 1886.

PLATE XXXVII

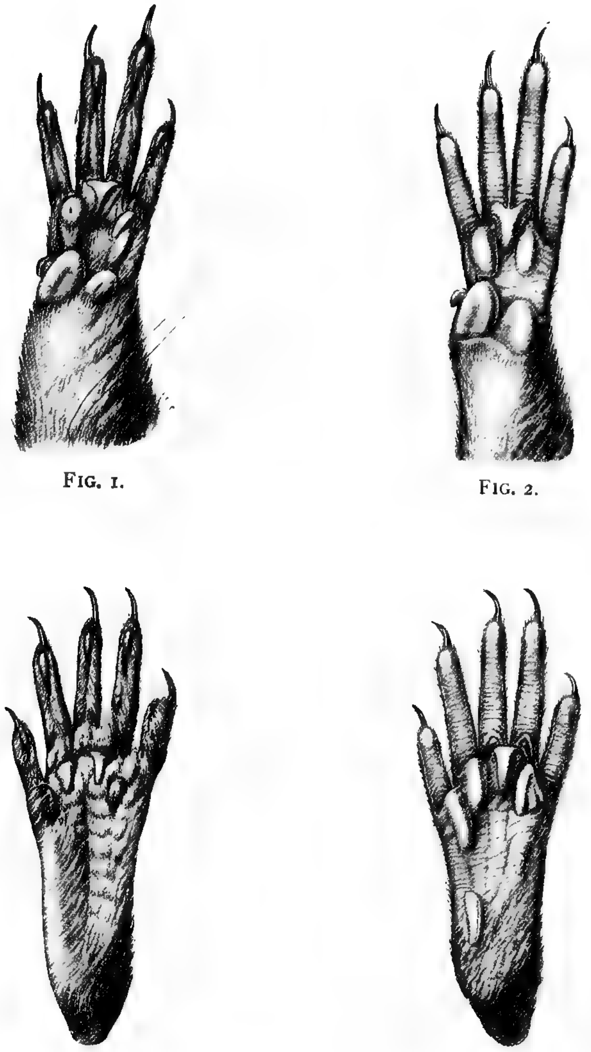

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

HANDS AND FEET OF THE SQUIRREL.

Left Hand.—Fig. 1 in Winter; Fig. 2 in Summer.
Left Foot.— Fig. 3 in Winter; Fig. 4 in Summer.
(Life size.)

and she is not afraid to approach within 4 or 5 feet of a man to scold him vigorously. There is a record of one which twice flew at a birdnester's throat, and cut his shirt with her teeth before she had to retire before superior force. After the retreat of an enemy the mother often removes her young, especially if they have been handled, from the nest to some place of supposed greater safety, bearing them in her mouth, and venturing away from trees and across roads. One young, while thus carried, was observed to occupy a position wrapped round the neck of the dam like a boa. But one which Mr W. Evans caused the mother to drop, and which he sent to Barrett-Hamilton in May 1911, was carried by the skin between the right fore-leg (arm) and the breast. Sometimes a female may be seen playing with and training her babies after they leave the nest, and this forms one of the prettiest sights of the woodlands.

Apart from man, and Martens formerly, the Squirrel does not appear to have many enemies in Britain. Owls, kestrels, and stock-doves sometimes occupy its drey, but probably not until after desertion by the rightful owner.[1] Mr Forrest once found a pair of stoats in occupation—a far more serious invasion. It probably suffers more diminution in numbers during hard winters than from any other causes, and great numbers are said to have perished in Upper Nidderdale during the very hard winters of the early eighties.

The Squirrel is liable to considerable variety in point of colour (*vide supra*, p. 697) the details of which were not properly understood until Mr Oldfield Thomas explained that much that was formerly supposed to be accidental is in reality normally recurrent each season as part of the animal's regular routine of moult and change of coat. This is particularly the case in regard to the cream-coloured tails, which were so long thought to be instances of irregular variation, but which are really characteristic of the animal and the basis of its scientific name.

The fur of the British Squirrel is no longer used in commerce, although at one time it was a favourite decoration for robes, and it is known to have been exported in quantities from Ireland (see p. 693). That of its continental relative is in request all over the world; formerly large numbers of the grey winter skins—called "Calabar" commercially—were imported into England for treatment by our furriers, but this trade is said to be now almost extinct. It is perhaps fortunate for our species that the excellence of its rabbit-like flesh seems to be unknown to the inhabitants of these islands; the attraction provided by a destructive animal with a saleable pelt and a palatable carcase might well have proved fatal to it.

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[1] For a record of a Squirrel being seized and carried away by a Tawny Owl, see R. W. B. in L. E. Hope and D. I. Thorpe (*Zoologist*, 1912, 184).

The Squirrel is well known as a pet, and its appearance and general liveliness must always make it attractive. But, unless taken young, it rarely loses its natural wildness, and it is usually quite sterile. Lataste remarks that it has a good memory for places, but it is full of irritability; he describes the wrath of one which, returning to its cage, found the door closed against it. It is, perhaps, not well to allow such a pet too much liberty, as it is mischievous and always ready to try its teeth on any objects which may come within its reach. However, if it be allowed liberty it forms, in one way, a very good pet for children, as Millais points out; for if at times they are apt to forget to provide their pets with meals, a Squirrel at large will usually contrive to forage for itself.

With regard to the longevity of the Squirrel, captives are said to have lived for nearly eight years; on the other hand Chalmers Mitchell (*P.Z.S.*, 1911, 446) found that of seventy-seven examples of *S. vulgaris* (probably including specimens of the present species) kept at the Zoological Gardens, the average and maximum longevities were only six and twenty months respectively. Many other *Sciuridæ*, however, did better in captivity; twenty-four American Grey Squirrels thus had average and maximum longevities of four and fifteen years respectively.

The Squirrel is used as a part of the arms of a number of English families, and has appeared at least occasionally on sign-boards.

The **American Grey Squirrel** (*Neosciurus carolinensis*, Gmelin), differing from *S. leucourus* by its much larger size and distinctive grey colour has been frequently introduced and liberated in this country during recent years; should it gain a good footing here, as seems not unlikely, it will prove probably to be a most formidable rival for our native species to face. A good account of the present status of this immigrant in Britain has been given recently by Boyd Watt (*Field*, 12th June 1915, 1044). From this it would appear that Mr G. S. Page, of New York, first liberated five of them in Bushey Park in 1889, but although one seen at Molesey in January 1909 may have been a descendant of these, the stock appears to have died out. They were next introduced, with embarrassing success, in Woburn Park, where "they increased so rapidly that it became desirable to reduce their numbers, and it is stated that about 1000 were killed during a recent winter, and 300 in one week." Steele Elliott, writing to Boyd Watt in July 1914, says that "in Bedfordshire the grey squirrel is numerous in the Woburn district and very common within a few miles of that centre. It has already spread north as far as Bedford, and other equally distant localities in limited numbers." It is now fairly common in Bucks, and specimens have been taken in Hertfordshire. Couples from Woburn were liberated in Regent's Park by the Zoological Society and these, possibly augmented by escaped pets, have greatly increased in numbers and have spread to Hampstead and Highgate. In Regent's Park, although still common, they are said to be "now disappearing, possibly from an excessive production of males" (*Official Guide to the Gardens*, 13th ed., 1915, 72). They are also to be found in Kensington Gardens and in Hyde Park. Other specimens from Woburn were turned out in Kew Gardens about 1905, and these seem to have spread to Richmond Park. At Kew, they are stated to have killed out or driven away all the native squirrels, but beyond this they seem to have caused little damage. On the other hand, the progeny of about thirty, also from Woburn, liberated at Scampston Hall, Rillington, Yorkshire, multiplied and spread so rapidly, and were found to be "so destructive that most of them have been got rid of after three years' constant warfare" (St Quintin, *Country Life*, 17th October 1914, 532). In Dumbartonshire, the species has been present since 1892 (Paterson, *Glasgow Naturalist*, 1912, 136; Boyd Watt, *ibid.*, 1913, 40), and it seems now to be in possession of a strip of country there, measuring about 20 miles long by 5 miles broad. During the winter of 1916-17 one appeared in Dalmeny Park, Linlithgowshire, coming to feed at the pheasant boxes. It was probably an escape from the Scottish Zoological Gardens at Corstorphine, where several have recently been at large (W. Evans, *in lit.*).

Boyd Watt says:—"As regards habits, the grey squirrel, like our native brown species, has many offences laid to its charge, and the judgment upon it is not always so lenient as that given above from Kew Gardens. From Dumbartonshire we are told that it is very destructive to the upper shoots of Scots pines. At Scampston Hall, Yorkshire, they caused much trouble in the kitchen garden, among the aviaries and poultry runs, and in woods of deciduous trees, and they also raided the gardens for small fruit. Two plantations of sycamores of about thirty years' growth had scores of trees ruined or disfigured—the bark being peeled off the leaders and upper laterals. The verdict of another observer is that they are destructive in gardens; damage the foliage of wych elms and horse chestnuts; consume quantities of walnuts, apricots, and other fruit, and dig up crocus bulbs. Apparently they are not so destructive to fir trees as the native brown squirrel, but are inveterate destroyers of eggs and young birds. In the Zoological Gardens they have been observed taking birds' eggs, or, if the young are hatched, they pull them out, or destroy the nests."

This species is now (November 1918) very common in parts of South Devon. Many individuals are to be seen in the Castle grounds at Exeter. According to Pocock, "it partially hibernates in London parks, or disappears for a few days in cold weather" (art. "Hibernation," *Encycl. Brit.*, 444). The same author states that males predominate in England (*Field*, 27th Jan. 1912, 187).

[GENUS CITELLUS.

1816. CITELLUS, Oken, *Lehrb. der Naturgesch. Th.* iii., *Abth.* ii., 824, the genotype being *Mus citellus*, Linnæus; Lichtenstein, 1825; J. A. Allen, *Bull. Amer. Mus. Nat. Hist.*, 16, 1902, 375; Miller.

1825. SPERMOPHILUS, F. Cuvier, *Dents des Mammifères*, 160 (genotype *Mus citellus*, Linnæus); Blasius and most authors.

The Sousliks, Spermophiles, or Pouched Marmots, as they are variously called, enjoy a wide distribution in the northern hemisphere and are probably of Asiatic origin. In the Old World they now range eastwards from Silesia, Bohemia, and Hungary, across Central Asia, but they are not known in Japan; southwards they are represented in Asia Minor, Palestine, and Persia, but do not reach the Himalayan region. In the Pleistocene period they occurred as far west as Denmark and the south of England. Part of the eastward recession of the genus has apparently taken place within the historic period, for Albertus Magnus observed Sousliks in the neighbourhood of Regensburg in the thirteenth century. In North America, Sousliks are found at all altitudes (between sea-level and 10,000 feet in California), from the Pacific Coast eastwards to the Central United States, and from Arctic Alaska southwards to Central Mexico. Although obviously of ancient standing, no fossil remains of the genus have been found, in either Eurasia or America, in deposits older than the Pleistocene.

The members of the genus *Citellus* may be regarded as degenerate squirrels. They have forsaken arboreal habits, and have colonised the treeless wastes. In these desert places they are strictly earth-bound animals, leading a great part of their lives in their burrows, and subsisting upon coarse herbage, varied with bulbs, seeds, and grain when available. They devour large numbers of insects, and like the true Squirrels betray carnivorous tastes whenever an opportunity presents itself. They form subterranean stores of provisions for use in inclement weather. In warm countries they remain active at all seasons of the year, but throughout the greater part of their range the Sousliks hibernate regularly, remaining in a torpid state in cold regions for a period of six months or more.

The acquisition of such habits has, of course, brought about a good deal of modification in bodily structure. Sousliks are animals of medium size. In general outward form they are essentially of sciurine aspect, although they are more robustly built than are most arboreal squirrels, and have relatively shorter peripheral parts. The fur is thin, coarse, and adpressed. The eyes are large. The ears very small (except in some American forms), clothed with numerous short and fine hairs, but without tufts. Cheek-pouches are present. The limbs are much shorter than in *Sciurus*, and in both hands and feet digit 3, instead of digit 4, is the longest. The vestigial thumb bears a small flattened nail; the other fingers are long, and armed with long, strong, and rather straight claws well adapted for digging. In the foot all five toes possess similarly shaped though shorter claws. The palms and soles, except towards the heel, are naked; on the palm there are five pads, on the sole four, the posterior two being absent; the under surfaces of the digits are annulated. The upper surfaces of hands and feet are well clothed with numerous long hairs which show a tendency to develop as lateral bristle fringes, especially noticeable along the outer margin of each hand. The tail is much shorter than in *Sciurus*, its length in European species ranging between one-fifth and one-third, instead of being about two-thirds, of the head and body measurement; cylindrical at its base, it is densely clothed with hair; and though far less bushy than in the Common Squirrel, it shows some trace of vertical flattening towards its termination.

The external differences between *Citellus* and *Sciurus* seem for the most part to be directly correlated with the more earth-bound habits of the Sousliks. Change of station has brought with it change of food, and this seems to be the chief factor which has influenced the development of the peculiarities of the dentition and skull in *Citellus*. The incisors are less adapted for gnawing than in *Sciurus*, being relatively weaker, less compressed laterally, and more nearly cylindrical in cross section. The cheek-teeth are $\frac{5}{4}$ on each side, as in *Sciurus*, $p\underline{3}$ being well developed though small. In form they are clearly more specialized than in the squirrel, and are adapted for the treatment of a coarser diet. In each upper cheek-tooth (except $p\underline{3}$) the single inner cusp and the two cross crests, which connect the inner cusp with the two chief outer tubercles, have become higher relatively and more apparent, forming a conspicuous U-shaped pattern in moderately worn specimens. Corresponding, though less obvious changes have taken place in the lower cheek-teeth. The skull and mandible under the influence of stronger muscles have become relatively robust, and far more massively constructed than in *Sciurus*. Earth-bound habits call for less mental activity than does an arboreal mode of living; the cerebral hemispheres are less developed than in *Sciurus*, and the fronto-parietal region is therefore flatter and much less boldly convex.

The advance of civilization, by bringing the waste places under cultivation, has brought the Sousliks into direct conflict with man at many points in their range. Cultivated plants have a higher food value than the natural herbage; and when man substitutes the former for the latter the Souslik population increases rapidly in numbers. In recent years these animals in California[1] and elsewhere have thus become numbered among the worst mammalian pests, inflicting enormous losses upon agriculture. These teeming Souslik populations have shown themselves to be liable to plague infection, and in this respect they constitute a very grave peril to the public health in many regions.

Fossil remains of *Citellus* were first discovered in the European Pleistocene by Kaup, who described (*Oss. Foss.* 1839, p. 112, Plate XXV., Figs. 3 and 4) a beautifully preserved skull, which was at first believed to have come from the Miocene *Dinotherium* Sand of Eppelsheim; this specimen formed the basis of Kaup's *Spermophilus superciliosus.* In 1842, Desnoyer and Prévost found abundant Souslik remains, which they referred to *C. citellus*, in the Pleistocene bone-breccia of the caves and fissures of Montmorency. Dr Hugh Falconer in 1859 was the first to detect the genus among British fossils, and in his posthumous *Palæontological Memoirs* (vol. ii., p. 472, 1868) two lower jaws from the bone-caves of the Mendip Hills, and another from the brickearth at Fisherton near Salisbury, are described and figured. To the Mendip specimens Dr Falconer gave the name *Spermophilus erythrogenoides*, but recent study tends to show that this name must be treated as a synonym of *superciliosus.* Since these earliest discoveries, remains of Sousliks have been found in numerous British and Continental deposits of late Pleistocene age. Many specimens were obtained by Dr Blackmore from the Fisherton deposit, while other observers have found remains in the later deposits of the Middle Terrace of the Thames at Crayford and Erith, in the fissure deposits at Ightham, Kent, and in the Langwith Cave in Derbyshire (Cheadle, *Proc. W. London Sci. Assoc.*, 1, p. 7, 1876; Newton, *Quart. Journ. Geol. Soc.*, 50, 1894, pp. 94 and 55, and 1899, p. 422; Mullens, *Derbyshire Archæol. Nat. Hist. Soc. Journ.*, 1913, p. 15.) In 1882 Mr E. T. Newton described (*Geol. Mag.* [ii.] ix., p. 51) some fragmentary remains found by Mr Clement Reid in the "Arctic Freshwater Bed" at Mundesley, Norfolk, these were referred provisionally to *S. altaicus* (= *eversmanni*). The Arctic Freshwater Bed lies beneath the well-known Cromer Till, and it is correlated by most geologists with the earlier Pleistocene horizons; the occurrence in it of remains of *Citellus*, a characteristically late Pleistocene genus, is one of the many facts which lead the present writer to correlate the deposit in question with the Third Terrace of the Thames, which is one of the later Pleistocene deposits (Hinton, *Proc. Geol. Assoc.*, xxi., p. 493, footnote, 1910.)

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[1] A most valuable account of the Ground Squirrels of California has been published recently by J. Grinnell and J. Dixon (*Monthly Bulletin of the State Commission of Horticulture, Sacramento*, vol. vii., pp. 597-708, 1919).

As regards the question of the species represented by the British fossils our knowledge is still incomplete. Dr Forsyth Major studied the material with great care many years ago, and we believe that he concluded that at least two species occur in the British Pleistocene; unfortunately his results were never published. The writer in turn has made some progress with a similar investigation, but has not been able to complete his work yet. In his view also there are two species at least, both extinct, one being allied to the living *C. erythrogenys*, the other more nearly related to *C. eversmanni.*]

ADDITIONS TO VOLUME II

SORICIDÆ.

Since the account of the *Soricidæ* (p. 76) was published, many Shrews from the Hebrides have come to hand, being among the fruits of the exploration of those islands organized by Mr W. R. Ogilvie-Grant. On most of the islands the Shrews found could not be distinguished from the corresponding species inhabiting the mainland of Britain; but the representative of *Sorex araneus* inhabiting Islay proved to be specifically distinct, and we described it in 1913 as a distinct species *S. grantii.* The account previously given may now be supplemented as follows:—

Sorex araneus castaneus (Jenyns).

Specimens indistinguishable from this form were collected by Mr R. W. Sheppard upon the islands of Great Cumbrae, Bute, Arran, and Mull; these were described by us in *Proc. Zool. Soc.*, 1913, p. 823. Similar specimens were collected on Skye by Mr P. D. Montague, and on Eigg by both Mr Montague and Mr D. Anderson. The Shrew found by Mr Sheppard on Jura made some approach in coloration towards the peculiar species discovered on the neighbouring island of Islay.

THE ISLAY SHREW.

SOREX GRANTII, Barrett-Hamilton and Hinton.

1913. SOREX GRANTII, G. E. H. Barrett-Hamilton and M. A. C. Hinton, *Abstract Proc. Zool. Soc.*, 13th April 1913, p. 18, and *Proc. Zool. Soc.*, 1913, p. 824; described from Islay, Inner Hebrides (type an adult female collected 26th April 1912, by Mr R. W. Sheppard, original number 76, B. M. No. 18.1.9.19.).

Distribution:—This Shrew is known only from Islay, where a series of twenty-two specimens were collected by R. W. Sheppard during his exploration of the Inner Hebrides (see footnote at p. 422 above).

Description:—This species is distinguishable at a glance from the Common Shrew of Britain by having its dusky upper side much more strongly contrasted with the light colour of the flanks. Its most remarkable character is seen in the dentition. The posterior or fifth unicuspid tooth of the upper jaw (*p*$\underline{2}$) is tending to disappear; in more than half of the individuals examined it is lacking, sometimes from one side of the jaw only, but more frequently from both sides. When this tooth is absent, the four remaining unicuspids appear to be somewhat enlarged in compensation.

In size and proportions *S. grantii* agrees fairly closely with English specimens of *S. araneus castaneus*, but averages slightly larger than Common Shrews from the Scottish mainland. The ears, hands, feet, tail, and the quality of the fur are as in the Common Shrew. With regard to colour, adults have the upper side of a deep blackish brown, perhaps darker than the "clove-brown" of Ridgway, the dorsal surface of the head and neck is slightly grizzled with tawny-brown, the under side is silvery or smoky-grey rather than yellowish or brownish as in *S. a. castaneus*, and this colour runs far up the flanks appearing in contrast with the dark upper side. Between the colours of the upper and under parts a narrow, inconspicuous, grey-brown flank-band intervenes, rarely it is "wood-brown," in which case it is more sharply contrasted with the back. The type and another female (collected 23rd April) are moulting into a scarcely less dusky summer coat. The adolescent pelage, judging from specimens collected in May and August, is of a lighter brown colour above, the precise shade being between "seal-brown" and "clove-brown," somewhat as in *S. a. castaneus*, with a flank-band near "wood-brown."

DIMENSIONS IN MILLIMETRES:—

No.	Date.	Head and body.	Tail (without hairs).	Hind-foot (without claws).	No.	Date.	Head and body.	Tail (without hairs).	Hind-foot (without claws).
SPECIMENS FROM ISLAY, CAUGHT AND MEASURED BY R. W. SHEPPARD.									
MALES.					FEMALES.				
73	24tb April 1912	75	36	13	72	25th April 1912	83	37	13
74	24th April 1912	77	36	13	*76	26th April 1912	75	37	13
77	26th April 1912	79	37	13	81	30th April 1912	78	36	12
80	30th April 1912	80	36	13	96	3rd May 1912	77	35	12
82	30th April 1912	80	36	13	106	10th May 1912	75	35	12
83	30th April 1912	80	37	13	157	3rd August 1912	75	38	12 juv.
84	30th April 1912	78	38	13	158	3rd August 1912	80	34	12·5 ,,
92	2nd May 1912	78	35	12	161	5th August 1912	73	36	12 ,,
95	2nd May 1912	75	35	12	165	8th August 1912	70	38	12 ,,
98	7th May 1912	75	35	12					
100	8th May 1912	75	35	12		Average of 18 adults of both sexes	77·3	36	12·6
101	8th May 1912	76	36	12					
105	10th May 1912	75	36	13					

* Type.

SKULL MEASUREMENTS IN MILLIMETRES:—

	S. a. castaneus. 15 Specimens from Jura, Mull, Bute, Great Cumbrae, and Arran.		*S. grantii.* 12 Specimens.	
	Maximum.	Minimum.	Maximum.	Minimum.
Condylo-basal length	19·0	17·7	19·8	18·2
Malar breadth	5·3	4·8	5·5	5·2
Interorbital breadth	3·9	3·3	3·8	3·5
Width of brain-case	9·6	8·9	9·6	8·9
Depth of brain-case	5·2	4·7	5·2	5·0
Maxillary tooth-row	8·2	7·6	8·4	7·8
p 4 to *m* 3	4·5	4·2	4·6	4·3
Mandible	9·8	9·0	9·9	9·3

The skull agrees in form and size with that of *S. a. castaneus*, but attains rather larger dimensions than skulls of the latter species from northern Britain and the Inner Hebrides.

The teeth agree in form with those of *S. araneus*, but there is no trace of pigment upon the hypocones of the upper cheek-teeth, nor on the protocone of $m\underline{3}$. The posterior unicuspid tooth $p\underline{2}$ tends to disappear, as shown by the following statistics:—

$p\underline{2}$ present on both sides of the jaw,	7	individuals, or	43·7	per cent.
„ absent from one side	„	4	„	25	„
„ „ both sides	„	5	„	31·3	„

When $p\underline{2}$ is absent the four remaining unicuspid teeth appear to be somewhat enlarged.

Status:—By colour and dentition *S. grantii* is clearly differentiated from all European members of the genus *Sorex*. Some of these, such as *S. araneus araneus* and *a. tetragonurus*, have the back as dark, but none shows the conspicuously contrasted sides. *S. grantii* may perhaps be regarded as an insular development from *S. a. castaneus*. It has maintained or acquired slightly larger dimensions than has the latter in the more northern parts of its range. The Islay Shrew has developed a peculiar colour pattern, and is now well on its way to reduce the number of the unicuspid teeth, perhaps because of a tendency to enlarge the anterior members of the series. The Shrew inhabiting Jura, while definitely a form of *S. araneus*, is geographically and morphologically the connecting link between *S. a. castaneus* and *S. grantii*; it has the small size and the dental characters of northern *castaneus*, but its colour pattern is modified somewhat so as to make an approach towards that of *S. grantii.*

Neomys fodiens bicolor (Shaw).

From Skye we received five specimens collected in June and July by Mr C. H. B. Grant. These differ in no way from the Water Shrew of the mainland.

RODENTIA.

MURIDÆ.

THE FOULA FIELD MOUSE.

APODEMUS FRIDARIENSIS THULEO, Hinton.

1919. APODEMUS FRIDARIENSIS THULEO, M. A. C. Hinton, *Scottish Naturalist*, November and December 1919, p. 177, described from the Island of Foula; type, an adult female, collected November 1917 (original No. 5.).

Distribution:—Foula (the Ultima Thule of Tacitus).

Description:—In general external appearance this animal closely resembles typical *fridariensis*, but differs in its smaller size and larger hind-feet.

Size small, the head and body measurement being scarcely greater than in *A. sylvaticus*, and therefore considerably less than in *A. f. fridariensis.* The tail is about equal to the head and body in length when all the specimens in adult pelage are averaged; but it is slightly shorter relatively in the larger or older specimens. The hind-foot is very large, its absolute size being as great as in the St Kilda Field Mouse, *A. hirtensis*, while its relative size is larger than in any other British form. The sole-pads are small as in typical *fridariensis.*

In colour the Foula Field Mouse agrees exactly with typical *fridariensis.* The flanks are dark, the lateral line of demarcation being regular and sharply defined. The ventral surface is of a dull bluish white, without any trace of a buffy suffusion. Normally there is no trace of a pectoral spot. The tail is strongly bicoloured, dusky above, white below. Dorsal surfaces of the feet white.

A direct comparison of the skulls suggests a closer affinity between *A. f. thuleo* and *A. f. grantii* than between the former and true *fridariensis.* The bullæ are as small, and the masseteric plate projects as little anteriorly as in *grantii;* while the brain-case appears to be still broader, rounder and more depressed than in the latter sub-species. In the mandible the coronoid process is very feebly developed as in each of the other sub-species of *fridariensis*, but its angular process shows no trace of the remarkable elongation characteristic of *f. grantii.* These appearances are borne out by the measurements, which in addition reveal some small peculiarities of the present form. The absolute size of the skull is about as in *f. grantii*, the occipito-nasal length, interorbital width, nasal length and width, and the length of the anterior palatal foramina, are dimensions which tend to be smaller relatively than in the other sub-species of *fridariensis;* while the zygomatic breadth, cranial width, and post-molar length tend to increase in relative value. The rostrum is relatively wider than in *f. fridariensis*, narrower than in *f. grantii;* the masseteric plate is relatively narrower than in *f. grantii*, much narrower than in true *fridariensis;* the length of the tooth-row is nearly as in *f. fridariensis*, distinctly shorter relatively than in *f. grantii.*

DIMENSIONS IN MILLIMETRES:—

No.	Date.	Head and body.	Tail.	Hind-foot.	Ear.	No.	Date.	Head and body.	Tail.	Hind-foot.	Ear.
	Males.						**Females.**				
	Skins—						*Skins—*				
1	Oct. 1917	96	..	24·2	16	5	Nov. 1917 (Type)	101·5	102	26	..
4	Nov. 1917	95	94	25·5	..	6	Nov. 1917	93·5	90·5	24·7	..
7	Nov. 1917	87·5	92	26	(juv.)	8	Nov. 1917	103·5	88	24·7	..
9	Dec. 1917	97	91	25	15	B	Nov. 1917	98	98	25	16
11	Dec. 1917	100	93	26	15·5	10	Dec. 1917	104	94·5	25·3	15·5
12	Dec. 1917	98	96	25·5	15·5	13	Dec 1917	91	92	25	14
15	Dec. 1917	90	88·5	25	15·5	14	Dec. 1917	90	90	25	14
	In Spirit—						*In Spirit—*				
	9th April 1917	89	92	23	15		April 1917	81	82	23	15
	9th April 1917	86	97	24	15·5		April 1917	86	83	24	15
	9th April 1917	77	83	23·5	16		April 1917	96	95	23·5	16
	9th April 1917	84	96	25	15		Nov. 1917	80	81	23·5	14
	9th April 1917	83	78	24	15		Nov. 1917	77	77	23	13·5
	Nov. 1917	82	82	23	15·5		Nov. 1917	82	81	22·5	13·5
	Nov. 1917	86	92	25	15		Nov. 1917	81	86	24	16
	Nov. 1917	85	84	24	15		Nov. 1917	91	98	24	16
	Jan.-Feb. 1918	94	..	25	15·5		Nov. 1917	87	..	24	14·5
	Jan.-Feb. 1918	86	87	23·5	15		Jan.-Feb. 1918	90	94	24	16
	Mar.-Ap. 1918	98	95	24·5	16·5						
	Mar.-Ap. 1918	88	95	23·5	15						
	Skeleton—										
2	Oct. 1917	101	..	25·2	16						
	Average of 20	90	90·2	24·5	15·4		Average of 17	90	89·5	24·2	14·9

COMPARISON OF EXTERNAL MEASUREMENTS.

	Absolute (in millimetres).				Relative (head and body = 100).			
A. fridariensis thuleo								
Average of 9 adult males . .	96·5	93	25·1	15·7	100	96·5	26·1	16·3
Average of 10 adult females .	95·8	94·2	24·7	15·3	100	98·5	26·8	16
A. fridariensis fridariensis								
Average of 6 adults . .	109·5	106·2	24·1	16·1	100	94	22	14·7
A. fridariensis grantii								
Average of 10 adults . . .	101·5	91·8	24	16·2	100	90	23·6	16·9

CRANIAL DIMENSIONS OF *A. f. thuleo.*

(Arranged for comparison with the Table at pp. 538 and 539.)

Number of Skulls examined :—8.	Measurements in millimetres.	Reductions.
1. Condylo-basal length . . . „ „ average	23·8 to 25 **24·5**	 100
2. Occipito-nasal length . .	26·1 to 27·2	108 to 109·5 **109**
3. Zygomatic breadth . . .	13·2 „ 14·1	54·9 to 56·5 **55·8**
4. Interorbital breadth .	4 „ 4·1	16 to 17·2 **16·5**
5. Cranial breadth . .	11·6 „ 12·2	47·8 to 49·2 **48·5**
6. Cranial depth (middle) .	8 „ 8·6	32·5 to 34·8 **33·4**
7. Condyle to m^3 . . .	11·2 „ 11·8	46·8 to 48·3 **47·3**
8. Condyle to front of bulla . .	6·4 „ 6·7	26 to 27·2 **26·6**
9. Nasal length . . .	9·5 „ 9·9	39 to 40 **39·5**
10. Nasal width	2·4 „ 2·7	9·75 to 10·9 **10·4**
11. Palatal length . .	12·5 „ 13·6	52·5 to 54·9 **54·1**
12. Diastema	6·9 „ 7·6	28·7 to 30·9 **29·5**
13. Incisive foramina (length) . .	5·5 „ 6·3	22·8 to 25·6 **23·8**
14. Incisive foramina (width) . .	1·8 „ 2	7·2 to 8·4 **7·7**
15. Rostral breadth	4·4 „ 4·8	18·2 to 19·2 **18·7**
16. Masseteric plate (least width) .	2·4 „ 2·6	9·9 to 10·7 **10·4**
17. Maxillary cheek-teeth . . .	3·6 „ 3·8	14·4 to 15·7 **15**

History and Status :—The material upon which this sub-species was based consists of thirty-seven specimens collected for Dr Eagle Clarke, chiefly by Mr W. H. Greenaway. Foula lies out in the Atlantic 16 miles west of the nearest point of the mainland of Shetland. It is 3 miles long and 1½ miles broad, with an area of little more than 5 square miles. Rising from the sea in lofty cliffs, which swarm with sea-fowl during the breeding season, its highest point attains an altitude of 1372 feet. Mr Greenaway found the mice, which are termed "Hill Mice" by the inhabitants, on rough ground from the foot of the hills up to 1000 feet above sea-level, and remarks that it is surprising how they survive the storms and trials of the Foula winter.

A. f. thuleo, while quite closely related to the other members of the *sylvaticus* group, is a very clearly defined insular form, best treated as a sub-species of *fridariensis*.

Since the "key" to British *Muridæ*, at p. 377 above was drawn up, our knowledge of the British members of the genus *Apodemus* has greatly advanced. It is now known that of the five species inhabiting these islands, three, *A. sylvaticus*, *fridariensis*, and *hebridensis*, have been differentiated into a number of more or less well-marked insular races or sub-species. *A. flavicollis*, confined to southern Britain, and *A. hirtensis*, inhabiting St Kilda, are each represented by a single form alone. The precise determination of Long-tailed Field Mice from the small islands off the British coast is a matter of considerable difficulty, calling for great patience, skill, and an accuracy of skull measurement and calculation, which in most cases will probably be beyond the powers of an ordinary field naturalist. It is impossible to frame a satisfactory "key" based upon either the external or the cranial characters alone; but the following "key," based upon both sets of characters together, sums up our present knowledge of this most difficult group and will probably assist future investigation :—

"KEY" TO BRITISH SPECIES AND SUB-SPECIES OF *APODEMUS*.

(A) Skulls of adults with post-molar region relatively long; the distance between a condyle and $m\underline{3}$ equalling 45.5 to 48.3 per cent. of the condylo-basal length, the average value of this dimension never less, and usually more, than 46.23 per cent. of the condylo-basal length.

  (*a*) Skull with feeble temporal ridges, and smoothly rounded brain-case; incisive foramina relatively long, their length from 21.9 to 25.5 per cent. (average 23 to 24 per cent.) of the condylo-basal length. Pectoral spot not developed as a collar.

    (a^1) Size smaller (head and body about 95, hind-foot about 22 mm.).

      (a^2) General dorsal colour brighter, tail longer, averaging more than 95 per cent. of the length of head and body. *sylvaticus sylvaticus*.

(b^2) General dorsal colour darker, with noticeable suffusion of black towards the rump, tail shorter, averaging about 90 per cent. of the length of head and body. . . . . . *sylvaticus butei* (Bute).

(b^1) Size larger (head and body more than 100, hind-foot more than 23 mm.).

(a^2) Head and body 129, hind-foot to 26.5 mm.

Coronoid processes of mandible normal. . . . . . . *hirtensis* (St Kilda).

(b^2) Head and body to 115, hind-foot to 26 mm.

Coronoid processes of mandible exceptionally short and slender.

(a^3) Angular processes of mandible normal. Pectoral spot entirely absent or vestigial, tail conspicuously bicoloured, relatively long (averaging 94 per cent. of the length of the head and body.

(a^4) Head and body to 115, hind-foot to 25 mm. . . . *fridariensis fridariensis* (Fair Isle).

(b^4) Head and body to 104, hind-foot to 26 mm. . . . *fridariensis thuleo* (Foula).

(b^3) Angular processes of mandible much elongated. Pectoral spot constantly present, though small, tail not conspicuously bicoloured, relatively short (averaging 90 per cent. of the head and body length). Head and body to 110, hind-foot to 25 mm. . . . *fridariensis grantii* (Yell).

(b) Skull with strongly developed temporal ridges and angular brain-case, incisive foramina relatively short, their length being 19.3 to 21 per cent. of the condylo-basal length.

Pectoral spot large, usually extended laterally to form a well-marked collar. . *flavicollis wintoni.*

(B) Skulls of adults with post-molar region relatively short; the distance between a condyle and $m\underline{3}$ equalling 45 to 47.1 per cent. of the condylo-basal length, the average value of this dimension never more than 46.23 per cent. and usually less than 46 per cent. of the condylo-basal length.

(*a*) Size large (head and body to 112, hind-foot to 25 mm.); dorsal colour not rufous.

(*a*¹) Skull slightly smaller (condylo-basal length to 24.7 mm.), ridges feeble, brain-case smoothly rounded anteriorly.

(*a*²) Ventral surface dark, pectoral spot often lengthened into a median longitudinal thoracic and abdominal streak. . . . . *hebridensis hebridensis* (Lewis).

(*b*²) Ventral surface silvery, pectoral spot absent or feebly developed. . . *hebridensis maclean* (Mull).

(*b*¹) Skull larger (condylo-basal length to 25.5 mm.), ridges comparatively strong, brain-case angular anteriorly. Belly silvery; pectoral spot evident. . . *hebridensis hamiltoni* (Rum).

(*b*) Size smaller (head and body to 95, hind-foot to 23 mm.). General dorsal colour rufous. Belly silvery; pectoral spot scarcely developed. . . . . *hebridensis cumbrae* (Great Cumbrae).

GENUS RATTUS (=*Epimys*).

On p. 575, *et seq.*, *Epimys* Trouessart is used as the generic name of the true rats. Hollister (*Proc. Biol. Soc.*, Washington, 1916, **29**, p. 124) has pointed out, however, that Fischer in 1803 (*Das National Museum der Naturgeschichte zu Paris*, Bd. 2, p. 128) used *Rattus* (misprinted *Ruttus*) for this purpose validly. The name *Rattus* must therefore supersede *Epimys*, a regrettable though quite unavoidable change. Hollister thought that *decumanus* (i.e., *norvegicus*, was the type species of Fischer's genus *Rattus;* but Thomas (*Ann. Mag. Nat. Hist.*, 18, p. 240), and Hinton (*Journ. Bombay Nat. Hist. Soc.*, 23, p. 59) agree that Fischer took *rattus* and not *norvegicus* as the genotype. The correct technical names of the species occurring in Britain are now therefore :—

1. *Rattus rattus*, with its sub-species *r. rattus*, *r. alexandrinus*, and *r. frugivorus.*
2. *Rattus norvegicus.*

1. *Rattus rattus.*

Since the account, at p. 592, of the **Geographical Variation** of this species was published, the house rats of India, Burma, and Ceylon have been studied by Hinton (*J. Bombay N.H.S.*, 28, pp. 59-88, 384-416, 716-725, 906-918, 1918 and 1919). This work was based upon the rich material gathered during the mammal survey of India, undertaken by the Bombay Natural History Society, as well as upon the collection in the British Museum. In the various Mammal Survey Reports published by Wroughton and others in the *Journal* cited, the Indian house rats were listed as "*Epimys rufescens*" when they had dusky bellies, and as "*Epimys rufescens*, var." when their under parts were white. That this difference in colour had some geographical value had long been apparent; and it was thought that the white-bellied and dark-bellied types might belong to two distinct sub-species or even species. To test this possibility was one of the chief objects of Hinton's work. The results arrived at may be briefly summarised as follows:—

The common Indian house rats, whatever may be their colour, are all referable to *R. rattus*; but the forms described as *R. nitidus* Hodgson, and *R. vicerex* Bonhote, about the status of which there has been controversy, are distinct species of the *R. rattus* group.

Like their European representative *R. r. frugivorus* in the Mediterranean region, the Indian white-bellied forms of *R. rattus* ("*Epimys rufescens*, var." of the Survey Reports) are essentially wild animals, often living out of doors in jungle and woodland in the most remote rural districts of India, Burma, and Ceylon. As wild mammals they show a definite geographical variation, so that many sub-species have now to be recognised. Descriptions of these are given in Hinton's paper.

With regard to the dark-bellied Indian house rats the case is different. Wroughton (*Journal* cited **23**, p. 474) had already put forward the view that the white-bellied forms of *R. rattus* in the Indian region represent the primitive wild form of the species, while the dark-bellied types have developed from these wild forms in response to changes of environment which have ensued upon the species becoming partly or wholly commensal with man,—the darkening of the under parts in the least modified of the Indian races, no less than the darkening of the back in the wholly parasitic *R. r. rattus*, being the outward indication of domesticity. These dark-bellied forms ("*E. rufescens*" of the Survey Reports) are in great measure restricted to the districts of India which possess substantial houses; and they are far less frequently caught out of doors than are the white-bellied races. Series of dark-bellied specimens from single localities or colonies are frequently very uniform in appearance and structure among themselves; but when series from different, though sometimes neighbouring localities are examined, an enormous range of variation is found. This variation, when not purely individual, proves to be of a colonial character and has little geographical value. It is therefore not possible to define sub-species or geographical races among the dark-bellied forms. In some districts, as in Kumaon, N. W. India, such rats seem to have little or no connection with the local white-bellied forms, in other places they differ from their white-bellied companions merely in colour and to a trifling extent in skull—the cranial differences being susceptible of physiological explanation; finally, in still other districts, the difference is purely one of colour, and even that sometimes breaks down. One may conclude therefore that the dark-bellied rats are of diverse origin; some seem to have been produced, in the localities where they are now found, from the local white-bellied race; others have found their way to their present habitations from other more or less remote districts of the country, or even from abroad; and lastly, many are doubtless to be regarded as the mixed descendants of both native and imported stocks.

The work now done, incomplete as it is, affords a perfect explanation of the conflict of opinion, with regard to the value of the species and sub-species recognised in recent zoological literature, which has arisen between systematic zoologists, and observers like Hossack and Lloyd studying rats in connection with plague in large towns or ports like Calcutta or Bombay. In such places it is hopeless to attempt to disentangle the history of the rats, for the urban rat population is a motley horde, representing the progeny of the truly native rats crossed with the descendants of old wanderers and with newcomers not only from the neighbouring hinterland but from all parts of the world. It is only in the rural districts that we can expect some measure of success to crown such efforts.

THE SMALL-MAMMAL PROBLEM.

During the war a great increase in the rat and mouse population of Britain became visible both in town and country. This rapid growth gave rise to alarm, which culminated in the passing of the "Rats and Mice (Destruction) Act, 1919." The abnormal increase was due to a combination of two entirely distinct sets of causes. Firstly, neglect and active folly pursued throughout a long course of years in the pre-war period, had together brought the rat and mouse resistance of the country down to a low degree. Thus few of our older buildings were, or have been made, rat-proof; and the stores of foodstuffs, and other materials attractive to rodents, in our warehouses, markets, and shops, remained without adequate protection from the ravages of rats and mice. Our waterways, sewers, and drains formed highways for, and harboured, hordes of Common Rats, which made their way, chiefly by means of unprotected drain-pipes, into the basements of adjoining buildings. In the towns, the underground kitchens, bakehouses, and other places in which human food was prepared, were regularly visited by droves of rats entering from the sewers and bringing filth and corruption into contact with the food of the citizens. Neither owner nor occupier of dilapidated rat-ridden property was under any obligation to repair and disinfest such premises; while many Local Authorities provided secure quarters and nourishment for the rat population by permitting the formation of great mounds of refuse upon waste lands in the vicinity of towns and docks. In rural districts, stackyards and farm buildings of all kinds were allowed to be entirely without protection. Still worse, in the interests of intensive game preservation and poultry farming, to the great detriment of general agriculture, every creature that could possibly be supposed to be inimical to game or poultry was (and still is) treated as "vermin." Summing up, we may say, that in 1914 we were negligently providing accommodation and nourishment for a vast rat and mouse population, although well aware that these rodents inflicted upon us a colossal annual financial loss and brought grave peril to the health of the community. In the towns, in order to keep the numbers of our guests in some control, we had to depend naturally upon the continuous employment of a great body of ratcatchers and a considerable annual expenditure upon the means of rat and mouse destruction. In rural districts we were no better off, for by allowing the countryside to be depleted of the natural enemies of rodents, the work of limiting the numbers of rats devolved to a large extent upon the gamekeeper and ratcatcher.

Secondly, the abnormal conditions which ensued upon the outbreak of war greatly aggravated the position, evil as it was in the summer of 1914. The accommodation available for rats and mice grew rapidly with the establishment throughout the country of vast camps and stores, housed for the most part in buildings of a fragile and temporary character; hundreds of new factories (with dwellings for workpeople), new docks, and even new towns came into being in response to military requirements, and every addition of that sort meant new quarters for rats and mice. In order to feed our forces and ourselves, enormous quantities of foodstuffs were imported, and warehoused in all parts of the country; many thousands of acres, previously untilled, were now brought under cultivation, and in laudable endeavours to increase the food resources of the nation, all classes devoted themselves to the cultivation of allotments and the rearing of poultry and rabbits. Such efforts greatly increased the food supplies accessible to rats and mice. As the war developed, labour was steadily diverted to military purposes; scavenger, rat-catcher, and gamekeeper disappeared. Regulations made under the Defence of the Realm Act prohibited the use of foodstuffs for the purposes of rat and mouse destruction. By such means we gave rats and mice shelter, sustenance, and security on a scale of unprecedented lavishness. The high fecundity of these creatures enabled or forced them to take quick advantage of these favourable conditions, and we were soon faced with grave peril. With the cessation of the work of the gamekeeper, the native carnivora began naturally to recover some of their lost numbers; but their relatively low fecundity, and the fact that they had been brought so low by pre-war vandalism, prevented them from increasing in due proportion with the increasing numbers of the rodents. Besides, the accommodation for carnivora was considerably decreased by the war conditions; not only were new towns and factories built in formerly wild districts, and waste lands brought under cultivation, but much of the woodland, the natural stronghold of most carnivora, was destroyed.

The rapid growth of the rat population caused public inconvenience and alarm; heavy losses were inflicted upon individuals and upon the State by the depredations of these animals, and it appeared not improbable that they were largely instrumental in disseminating various epidemic diseases then ravaging the civil and military population. Towards the close of 1917 considerable outcry against these pests arose; and was met by the issue of emergency regulations by Government departments. The Ministry of Agriculture and Fisheries formed a special Rats Branch, and in 1919 the emergency legislation was embodied, extended, and permanently established by the Rats and Mice (Destruction) Act.

In view of the importance of this matter, and of the expense and not infrequent hardship, which the proper administration of this Act will entail, it will perhaps not be thought out of place if we discuss some scientific considerations bearing upon the rat and mouse problem. We will in the first place deal with some points of interest in connection with the destruction of rats and mice. Secondly, we will try to show that the problem of the rat and mouse is only one branch of a far greater problem involving not one or two species merely but all small mammals. That greater problem must be solved in the near future, for with the growth of civilisation it confronts us in all parts of the globe. Even so far as Britain is concerned, the Act does not solve the problem, although undoubtedly it is the first step in the right direction yet made by the legislature.

The Act aims at bringing about a great reduction in the rat and mouse population. It imposes certain obligations upon, and gives certain powers to, County and Local Authorities, the general administration of the Act being entrusted to the Ministries of Health and Agriculture. County Rat Officers have been appointed for the purpose of putting the Act into practice; and the owner or occupier of rat-infested premises is now compelled to free his premises from infestation and to put his house in order. All this is good and should lead to a rapid improvement in existing conditions; and from the Rat Officers we may hope to obtain a great deal of information.

The high fecundity of our parasitic rats and mice makes it very difficult or impossible to exterminate any one of these species by methods of active destruction alone. The best information, at present at our disposal, concerning the breeding rate of any of the three species inhabiting Britain is that furnished for *R. norvegicus* by Petrie and Macalister.[1]

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[1] Petrie and Macalister in "Reports and Papers on Suspected Cases of Human Plague in East Suffolk and on an Epizootic of Plague in Rodents." *Reports to the Local Government Board on Public Health and Medical Subjects*, N.S., No. 52. London 1911, p. 58.

In 1911, between 16th January and 14th February, these observers examined 6071 individuals, collected in Suffolk and Essex during the period specified. Of these rats 3273 were males, 2724 females, and of 74 the sex was not recorded; 290, or 10.6 per cent. of the females were pregnant, the average number of embryos in each being 9. Had the count been made in warmer months of the year a higher percentage of pregnant females would doubtless have been observed. It is clear from these statistics that many more rats are born than can possibly survive; limitations of space and food ensure that a large proportion of all the young born must perish before attaining sexual maturity. If from any cause the mortality among the adult rats is increased, competition for food and space is diminished and the chances possessed by the young of reaching sexual maturity are increased proportionately. From the data cited it is possible to form an idea of the maximum monthly loss which the rat population can sustain without fear of extinction. We are thus able to gain a rough notion of the magnitude of the task of rat extermination, and to realize the necessity of following up each campaign by another. For, assuming Petrie and Macalister's results to apply throughout Britain at all seasons, it may be shown that, provided there is sufficient food and space, the rat population can double itself in about seven years, even although we assess the monthly mortality among the sexually mature individuals at 10 per cent., and assume that 75 per cent. of all the young born perish without reaching sexual maturity.[1] High mortality among the young can only be

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[1] The calculation upon which this statement is based is as follows:—Of 5997 rats 3273 or 54·5 per cent. are males, 2724 or 45·5 per cent. females. Of the females, 290 or 4·85 per cent. of the total stock give birth to litters of 9. Assuming a mortality of 10 per cent. among adults and 75 per cent. among the immature in each month, R in the following equation represents the number of rats living in any given month for each 100 rats living in the next preceding month.

$$R = \overset{\text{♂}}{54{\cdot}5} + \overset{\text{♀}}{45{\cdot}5} - 10 + \frac{4{\cdot}85 \times 9}{4} = 90 + 10{\cdot}91 = 100{\cdot}91.$$

Applying the formula given for compound interest, where

$t = \dfrac{\log. a - \log. p}{\log. R}$ we find that the rat population doubles in 79·5 months.

The equation shows that, with the rates of mortality assumed, the rat population would increase if 4·45 per cent. of the population gave birth to young in each month; while if less than 4·4 per cent. gave birth to young it would decline.

maintained by the pressure of competition or by extreme persecution; the greater the loss inflicted upon the rat population the more rapid the rate of recovery.

Rodier, dealing primarily with the rabbit pest in Australia, has advanced an ingenious plan for controlling the numbers of rodents. He thinks we should aim at producing a vast excess of males. Rabbits, rats, or mice should be trapped alive; the females should be killed and the males given their liberty. By this proceeding a great disparity in the numbers of the sexes will be produced in due course, and a keen competition will arise among the males for the possession of the surviving females. The males will fight each other continuously, and they will, at all times, relentlessly pursue and harass the females. The nursing does will be unable to rear their families, and any species attacked by this system will become rare if not extinct. The present system of indiscriminate trapping and poisoning, according to Rodier, has a directly opposite effect; it ensures the destruction of the surplus males, and results in fertile unions for all females.

Rodier's scheme has been advocated recently by Mr G. Jennison,[1] who has been experimenting for some years at the Manchester Zoological Gardens. He states that "our present system of destruction helps the rat in the struggle for existence. The more rats killed, the more food for the remainder; the more males killed, the greater the chance for the doe to breed quietly and raise her offspring. These two facts together neutralise all the good effects of indiscriminate slaughter. The rats can be reduced quickly to a certain point beyond which it is almost impossible to make further progress, and from which they soon reach their former numbers if at all neglected, *e.g.*, Copenhagen caught 100,000 in four months, 8th August to 8th December 1904; they could still catch 99,000 in the three months of July quarter 1908, under the new rat law." Applying the Rodier system to the Bellevue Gardens, Manchester, Jennison reduced the number of rats caught there from about 34 per month at the end of 1915, to 18.5 per month in the first six months of 1920. He says "the best plan for rat destruction appears to me plain.

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[1] G. Jennison, "Rat Repression by Sexual Selection," *J. R. San. Inst.*, xli., 358.

Where rats are very numerous, apply twelve months of intense slaughter, which will bring the problem within manageable limits; then apply the Rodier system. Its great merit is the lengthy period of neglect that an area well in hand can sustain before becoming, if it ever does become again, a nuisance; its defect is solely the difficulty of execution. Rat-poisoning must cease, and rat-killing as a sport must be banned, though a careful man may shoot with safety rats carrying food, as the does alone perform this duty."

Mr E. Read, chief of the Rats Branch of the Ministry of Agriculture and Fisheries, has been kind enough to inform us of a method, discovered by the work of his department, by which the Rodier system can be applied in a practical and wholesale manner, without the initial trouble of capturing the rats alive and determining the sexes. During the earlier winter months, *e.g.*, November, poisoning with a preparation of liquid extract of squill and milk has been resorted to, and many thousands of rats have been killed in all parts of the country by this means. Of the total number killed in this way at this season, no fewer than 85 per cent. were females, the milk proving to be an irresistible bait for the does nursing families at the onset of the inclement season. The Rodier system deliberately and generally applied could show no better result than this, because even with it, accident and error in the determination of sex would certainly lead to the death of many males. From this experience it would appear that active rat destruction should take place chiefly in the winter months when the does are hard pressed; the other months should be used chiefly for preventive work such as rat-proofing.

Scientific study confers a measure of foresight, and it is often possible to predict many of the consequences which must flow from current actions. The small-mammal problem is one of the things pre-eminently susceptible to treatment by intelligent anticipation, and with our knowledge and experience, we certainly ought not to be content with merely devising expedients to cope with the difficulties of to-day, heedless of the perils of to-morrow. Given sufficient determination, money, and patience, we might, in the course of time, succeed in exterminating both species of rat and the House Mouse in

Britain. But such success would not bring with it the real fruits of victory; the small-mammal problem would still remain, demanding urgent solution from the inhabitants of this island.

The problem in question has arisen in this, as in all other countries, as one of the many far-reaching consequences of human interference with the working of the "Balance of Nature." Small mammals, like humanity, feel the pinch of cold and hunger, or the pain of heat and thirst; accordingly they welcome shelter from the weather, food and drink in plenty, and security from their foes. Wherever man in the presence of a wild mammalian fauna, contrives a shelter for himself, his goods, or his domestic animals, there will always be a greater or less number of species quick, if not prevented, to enter into an uninvited partnership with him, sharing his joys and, it may be, increasing his sorrows. Among mammals, no doubt, murine rodents show the quickest appreciation of the benefits conferred by unintentional human benefaction; and they are generally the first wild mammals to become commensal with man. But the power to force an undesired alliance upon careless humanity is not restricted to the Muridæ among rodents, nor to the rodents among mammals; it is shown in various degrees by such different Orders as the Chiroptera, Insectivora, and Carnivora. Individual species belonging to these other Orders like *Pachyura gigantea*, the Indian Musk Shrew, may become thoroughly parasitic, and acquire greatly extended distributions in consequence.

Among Muridæ, at the present time, three species alone claim so much attention because of their parasitic habits, that there is danger of our overlooking the claims of their rivals in such a connection. Two of the three, the House Mouse and *R. rattus*, had the good fortune to live originally in the cradle of civilization. Possessing habits which permitted a close association with humanity, they entered the earliest houses, and with civilized man they have spread over the greater part of the globe. The third species, *R. norvegicus*, is a native of a more remote and desolate region; widely different in habits from either House Mouse or *R. rattus*, and habitually shunning the presence of man, it had to wait long for an opportunity of invading Western Europe. Once introduced, it made rapid progress, finding congenial surroundings in the cellars and drains of the towns, and along the banks of the rivers and canals. As described above (p. 583), the coming of *R. norvegicus* to Britain led to the almost complete extinction of *R. rattus* as an inland inhabitant of this country during the eighteenth and nineteenth centuries. Quite recently, however, *R. rattus* has been recovering its lost ground—a fact of importance in connection with the argument now being presented.

When *R. norvegicus* arrived in Britain, in the early part of the eighteenth century, it found *R. rattus* in complete possession. At that date rat-proofing was not attempted, and the rat population in the towns was kept in control by the ratcatcher. So far as human intervention was concerned, both species were upon terms of equality. In these conditions, favoured by its own constitution and character, *R. norvegicus* triumphed and *R. rattus* was defeated. In the later part of the Victorian period it was difficult to procure any example of the latter species away from the vicinity of the docks. Towards the end of the nineteenth century, and in later years down to 1915, great changes took place in many of our cities. Many of the older houses were demolished, and upon their sites were erected buildings of stone, characterised by a lavish use of cement in their foundations, as well as by the possession of perfect sanitary appliances and well-guarded drains. These buildings, particularly the most modern examples, are for the most part proof against rats seeking entrance through basements, and therefore they remain free from infestation by *R. norvegicus.* But *R. rattus* is primitively an arboreal species; and telephone wires and cables now extend from building to building, bridging the streets. The chief waterside colonies of *R. rattus* to be found in our ports are situated for the most part in lofty, solidly-built warehouses. These rats issue from the upper floors of the dockside premises, and pass along the telephone wires to the roofs of other buildings. Roof kitchens are among the improvements of the modern structures, and *R. rattus* soon invades them, effecting an entrance from the roof through skylight, window, or ventilator. In this way new colonies are formed at increasing distances from the docks, and in many towns, as in London, the species is regaining ground lost in the preceding two centuries. Here we have an excellent example of the working of the Balance of Nature even in the heart of a great city. So long as *R. norvegicus* and *R. rattus* compete on level terms, in a temperate country, the former must win; but if the former be denied access to a building which remains open in some way, and attractive to *R. rattus*, the latter will enter and thrive in its security from competition.

There was a time when Britain possessed no member of the genus *Rattus*. At that date the House Mouse, which arrived from the East possibly with the Neolithic or Bronze Age people, was in full possession of the dwellings. On one view of the evidence, the fact that the House Mouse has developed special insular forms, like those of St Kilda and the Faroes, might be cited as proof that *Mus musculus* had already made a conquest of human households and baggage at the dates when the first wanderers landed on those remote islands. Be that as it may, there is no reason to doubt that before the arrival of the Black Rat, the House Mouse filled all the accommodation available for parasitic Muridæ in Britain, and if rats had not arrived in Britain to claim their present large share of the existing accommodation, all, in so far as it is suitable to *Mus musculus*, would now be filled by House Mice. The presence of a rat population keeps the numbers of mice in strict and proportionate control; what the House Mouse population of the country can be at any given moment is limited by the size of the rat population among other things.

There are still some countries not yet colonised by *R. rattus* or *R. norvegicus*, and where the House Mouse is unknown. Yet in these countries the small-mammal problem is felt just as acutely as in the centres of European civilization. Native Muridæ swarm in the houses of Central Africa, and during recent years elaborate, costly, but fruitless attempts have been made to exterminate these pests there. In those parts of America where the exotic *Murinæ* have not yet obtained a footing, the native *Cricetinæ* play the parts of house mice and house rats. Nor need we go so far afield; many of our own country houses are infested by *Apodemus*, more rarely by *Evotomys*, and even on occasion by the exclusive *Arvicola amphibius*.

Station, habits, and food, no doubt, are regulated for each species to a considerable degree by the constitution of the species; but often, changing circumstances betray the fact that the familiar and apparent limitations bounding the range of individual choice are not those imposed upon a species by any inelasticity of its own constitution, but are such as result from extrinsic influences such as the competitive presence of other creatures. Exterminate a species from a given area, and many different claimants for the vacant place rapidly appear; no one of those claimants, perhaps, will be able to fill the whole vacancy, but between them all it is soon filled. In each case the driving power comes from within; "increase and multiply" carries "colonize or perish" as its corollary; few individuals die voluntarily.

It is, of course, necessary to-day to wage an active war against both species of *Rattus* and against the House Mouse, not only throughout Britain, but aboard the shipping in our ports. The numbers of these rodents living in our midst are far too great, putting the public health in peril and occasioning serious economic loss; they must, therefore, be reduced. But mere extermination of these species is not, and cannot be, a solution of the small-mammal problem. The mere killing of a great number of individuals relieves the survivors from much active competition for food and space, and ensures a more rapid rate of breeding. The killing of an old male rat at once provides food and space for three or four immature rats that otherwise would have perished. Extermination of *R. norvegicus* must inevitably result in better chances for *R. rattus* in the struggle for existence. Extermination of both species of rat must enormously increase the space and food available for *Mus musculus.* The elimination of these alien parasitic Muridæ must inevitably bring us into conflict with our native members of the family. That the latter, hitherto, have not to any large extent invaded our houses and towns is due solely to the fact that the alien species are already in possession, and have been, so far, strong enough to keep the native forms outside in the cold. The extermination of all Muridæ, native and alien, from Britain would merely disturb the Balance of Nature in favour of other groups of small mammals, and most probably in favour of many other organisms also. An attempt to solve the small-mammal problem by purely destructive methods is doomed, therefore, to failure; it opens a vista of endless strife with the organic world, fraught possibly with great danger from unforeseen consequences, infinite expense, and no satisfaction.

Small mammals in themselves are not evil things; on the contrary they play a great part in that complex natural mechanism by which all animals and plants are brought into relation with each other; a mechanism in which every living thing has to do its exact share of the work of keeping the face of the earth variegated and happy. Aware of this fact, and of the complexity of the relations subsisting between each and all species, it becomes impossible to assert with confidence that we can afford to dispense entirely with any single species now forming part of the British fauna. It is only when man, disturbing the Balance of Nature for his own ends, unduly favours one species or group of species, that evil results from small mammals. "Noxious species" have become "noxious" in consequence of our own carelessness and stupidity; to eliminate them, and to remain careless and stupid, is merely to invite other species, at present innocent, to stray and become "noxious" in turn.

Considerations of health and economy forbid all thought of leaving the small-mammal problem unsolved. Simple destructive methods alone, as shown above, will not solve it. To devise adequate preventive methods seems therefore to be the only course now left open to us; in such methods alone can we hope to find a real solution to the problem. The most serious objection to preventive methods is their cost. To put in practice a vast scheme of rat and mouse proofing will cost an immense sum of money, and it will tax the national energy and resources for many years. A cheap remedy for ills springing from the negligence of two thousand years is, however, more than we can reasonably expect. Every farthing spent on prevention will produce permanent benefit; while sums spent upon mere destruction of rats and mice can procure no more than temporary relief.

The preventive methods contemplated are of two kinds.

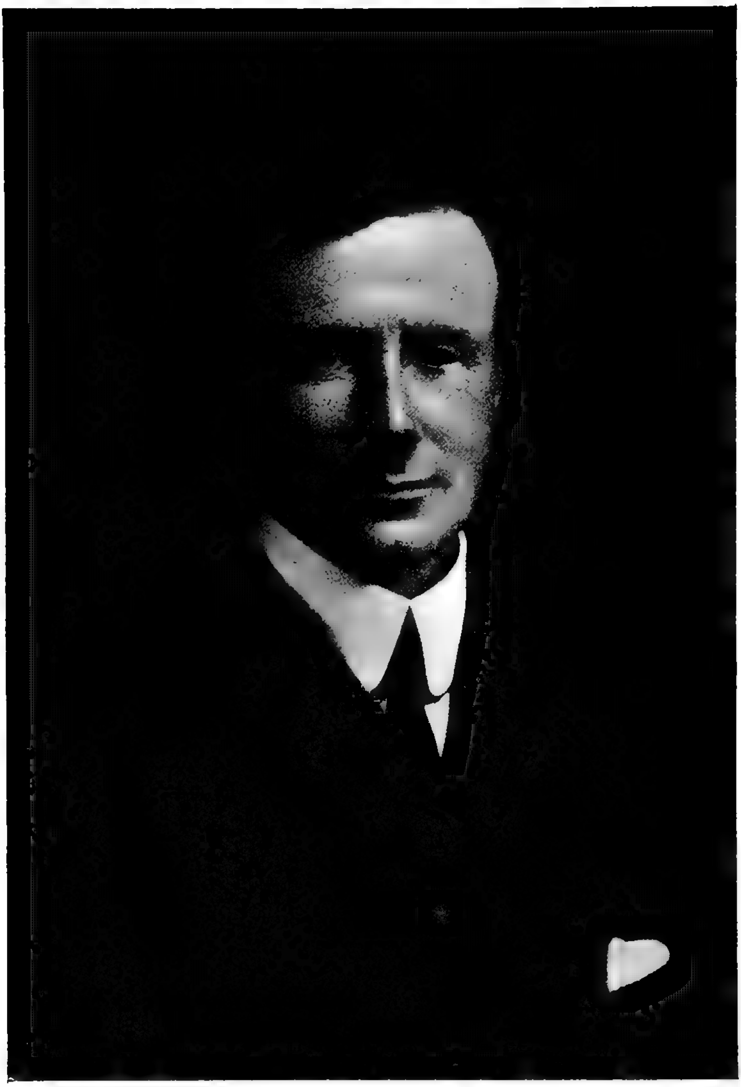
Firstly, we must learn to deny unnatural shelter and food supplies to small mammals. Secondly, we must not give them an unnatural security from their enemies in the open country.

All new buildings in town or country should be of rat-proof construction; especial attention should be given to buildings destined to house great quantities of foodstuffs. Among existing buildings, those which are rat-ridden should either be disinfested and repaired, or else they should be demolished. Many a house at present infested could be cleared of rats and mice, and made practically safe from further invasion were two or three drains properly sealed, or a broken ventilator or so repaired. "Shelter" and "food," of course, must be construed liberally; for the dump of rubbish standing for years on a piece of waste ground, or the unguarded sewer and its filthy contents, may provide small mammals with both palatial accommodation and regal fare. At all times special attention should be given to the protection of human food supplies, to stables and other places in which domestic animals or their foodstuffs are kept, and to the collection and disposal of garbage. There are many ways of protecting cornstacks and the like from the attacks of rodents, and the adoption of one or other of such means should be insisted upon.

The effects of all such preventive measures should be carefully watched and studied. As described above, many modern buildings, successfully resisting the attacks of *R. norvegicus* from below, have been invaded by *R. rattus* from above. Had the telephone cables been provided with rat guards, no trouble with *R. rattus* would have ensued. At every step, therefore, we must be on the alert, lest in shutting the door to one species, we open a way for another.

Although we can and should protect such things as farm buildings and cornstacks, it is impossible to make the open fields rat or mouse proof. And if we were able to do such a thing, it might be very far from advantageous to attempt it. But Nature has provided the best means of keeping the rodent population in control in the open country—a means which will not fail us if we do not seek its destruction, and if we do our part by denying, as far as may be, all unnatural shelter to small mammals. Our rural rodent population will then be kept within bounds by the action of the weather, and of its chief enemies, the carnivorous mammals and birds. It is of vital importance, to general agriculture and to the nation at large, that we should preserve a sufficiently strong carnivorous element in our fauna. We possess no better friends than the Weasel, the Stoat, our native Owls, and the Kestrel, since small rodents form the staple food of all these animals.

But our carnivora are systematically persecuted throughout the country and brought to the verge of extinction. The game preserver endeavours to rear annually a stock of game far in excess of the natural capacity of his estate, hoping each season to produce a great surplus which he may destroy for pleasure and profit. This cannot be done to so large an extent in the presence of carnivora as in their absence; carnivora will help themselves to part of the surplus produced. Therefore carnivora are proscribed; and the preserver and his keeper ruthlessly destroy that, which, in the national interest, should be carefully protected. It is said that the rearer of poultry will suffer if carnivora become abundant. But it must be remembered that carnivorous tastes are not peculiar to the Order Carnivora or to the Birds of Prey; the development of such a taste is often a mere matter of opportunity, and the Common Rat frequently shows itself to be as carnivorous, and as destructive of life as any species of true carnivore, its crimes being often laid at the doors of other species. If the poultry farmer, the fancier, and the game preserver protect their stocks from the ravages of the Common Rat, they will have little to fear from the much hated carnivora. Everything in this world has its price, and carnivora do not form an exception to that rule; we need them and must pay the price, but whether we buy cheaply or dearly depends entirely upon ourselves.



Yours faithfully.
Edward. A. Wilson.

1910.

EDWARD ADRIAN WILSON

AN APPRECIATION

WHILE the whole civilised world mourns for the gallant men who perished during the British Antarctic Expedition, the author and publishers of *A History of British Mammals* especially feel the loss of one who was not the least heroic participator in that glorious misadventure, Dr Edward Adrian Wilson, our artist.

Encircled as his name is by the halo of a rare achievement, he represents to those who did not know him personally, something removed above the humdrum existence of ordinary men. To us he was a comrade, workmate, warm-hearted friend of very visible and entirely human flesh and blood.

On the return of Captain Scott's first Antarctic Expedition in the *Discovery* in 1904, Wilson, hitherto practically unknown either as artist or zoologist, attracted much attention by his marvellous rendering of Antarctic scenery and animal life. His pictures of the seals and penguins brought those, at that time almost apocryphal creatures, before the public with a vigour, fidelity of attitude, and brilliancy of colouring never, we believe, previously attained.

In admiration of these paintings we opened up negotiations with the object of securing his services for our illustrations, negotiations which were not hindered by the fact that author and artist had at Cambridge attended the same lectures, frequented the same laboratories, and finished equal in the Tripos of 1894. To complete the parallel, both were candidates for appointment to the scientific staff of Scott's first Antarctic Expedition (1901-4), for which one alone could be accepted. To the rejected applicant fell the consolation of compiling for the use of his successful "rival" the chapter on seals in the *Antarctic Manual* (1901).

We considered ourselves exceptionally fortunate when Wilson found himself able to undertake the work, and he threw himself into it with all the ardour and enthusiasm of the simple-minded naturalist that he was. The "free hand," so often longed for, so rarely permitted, was granted, the result being a long series of drawings which we contend mark a new epoch in the illustration of a British book of the present class. The only cause for regret is that the processes of reproduction have toned down Wilson's colour, always his strong point. So keen was he about his illustrations, that he made a special journey to Shetland to study whales at the whaling stations; and he confidently hoped to bring back from his long voyage to the Antarctic much new information to form the basis of further illustrations of the Cetacea.

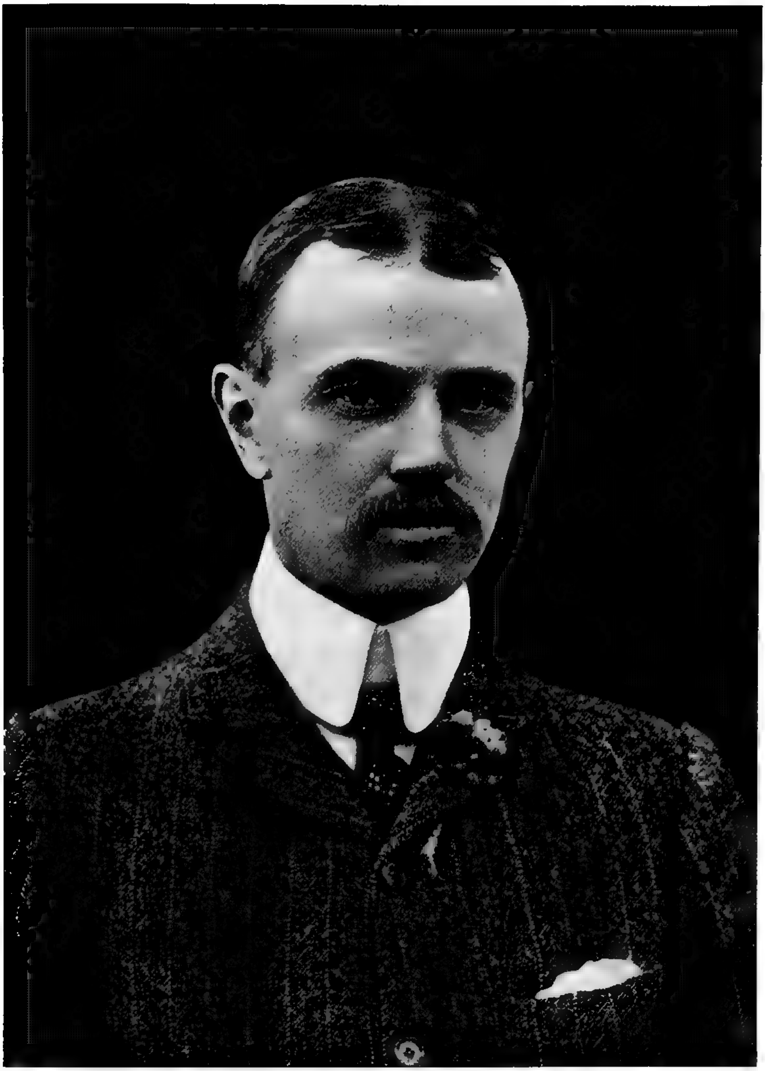
On Wilson's second departure to the Antarctic a few drawings were still wanting to finish the scheme, and we think we may congratulate ourselves on having secured Mr Guy Dollmann, of the British Museum of Natural History, to complete the task. Mr M. A. C. Hinton has also supplied many technical drawings, his unique knowledge of the skulls and teeth of our extinct micromammalia making his work peculiarly valuable.

Of the man Wilson we say little, as he himself would undoubtedly have wished. Simplicity, straightforwardness, patience, enthusiasm, were all strong points in his character. One could not associate with him without feeling that one had gained something. While his natural breadth of mind must sometimes have revolted against the minute detail inseparable from mammalogy, he yet lavished the most careful attention on the numerous technical diagrams, to master the meaning of which meant much study on what was to him a novel subject. A dreamer of great dreams, it was sometimes necessary to call him to earth for a demonstration on murine osteology, but no man ever took criticism in better part. As a rule he forestalled it by a genial counter attack :—"You are so polite this morning, that I know you are going to tear my drawings to pieces," was his typical opening to a discussion. Like all geniuses, he was full of contradictions; a delicate man, he yet went to the Antarctic "for his health," and when asked to explain this paradox, remarked that he never felt the *joie de vivre* till he was on a sledge journey. His unselfishness resulted in his undertaking during the first expedition the odious but necessary duty of daily slaughtering a sledge-dog to be devoured by the rest of the team; it was no less characteristic of his nature to find philosophical reflections on canine psychology in that unpleasant task.

Wilson has gone! His long, lean figure will no longer stalk down the galleries of the British Museum of Natural History to a conference on Mammal illustrations, but we, his fellow-workers, will treasure his memory, proud that for a brief space he journeyed with us, lightening our labours with the encouragement of the truest good-fellowship.

GERALD E. H. BARRETT-HAMILTON.

The accompanying signed portrait was presented to the publishers by Dr Wilson on the eve of his departure to the Antarctic.



[Photo: Poole, Waterford.

Yrs truly,
G. E. H. Barrett-Hamilton

GERALD EDWIN HAMILTON BARRETT-HAMILTON

AN APPRECIATION

IN the last number of the *History of British Mammals* there appeared a beautiful appreciation of Edward A. Wilson, the artist and companion in death of Captain Scott, written by the author of the work, and now, to the deep regret of all who knew him, the very next number of his much-loved book has to be prefaced by a notice of Barrett-Hamilton's own death, a death curiously parallel to that of his friend. The two, as Barrett-Hamilton tells us, had known each other from their college days, had both wished to go on Scott's first Antarctic expedition, and each had helped the other in the scientific work which resulted from that first expedition—while from the second there was to be no return for Wilson. But a short period elapsed, and Barrett-Hamilton himself accepted a somewhat similar mission—to go to South Georgia to observe the whale fishery now being carried on in high Southern latitudes with so much success as to threaten the extermination of the whales; to study and note the characters and habits of these animals, and to get what scientific collections he could in that almost Antarctic region. All had gone well to the end of the year, but in January the news was telegraphed home that he had died of heart-failure on the 17th of that month. Barrett-Hamilton, like Wilson, died on duty in obedience to the dictates of that spirit of scientific enterprise which had already caused the loss of his friend.

My own acquaintance with him dated from the same time as Wilson's—his undergraduate days—when I was pleased to see some papers appearing on British Mammals, and hastened to press their author into the service of technical mammalogy, by enlisting his help for the National Museum. For some years while "eating his dinners" for the Bar, Barrett-Hamilton worked regularly at the Museum, taking for his speciality the Palæarctic Mammalia, in the same way as Bonhote was then doing for the Oriental ones, De Winton, Schwann, and Wroughton working in succession at those of Africa. During this period he wrote such monographs as were possible on the material then available, and thus paved the way for the general work on British mammals on which he early set his heart, and which he lived to carry so far that it will remain a monument to his memory, even if the final parts have to be completed by others. It was his early work on European mammals that made it evident that much more material was needed to deal adequately with the subject, and firstly by the late Lord Lilford's generosity, and later by more systematic and official endeavour, the great collection was built up on which Mr G. S. Miller's *Mammals of Western Europe* was based, this book in its turn being constantly called on for help in Barrett-Hamilton's own especial work.

Full of the spirit of adventure, Barrett-Hamilton's scientific life has been interrupted by several missions abroad. These were either in the cause of science, as when he went to the Alaskan seas to study the life-history of seals, and again on the last fatal expedition, or in the national service of his country. For he went to South Africa to serve in the Boer War, an occasion when he by no means forgot his scientific tastes, as he made considerable collections at the dreary outpost where he spent most of his time.

Of late years, after he had married and settled down on his father's estate in Ireland, his visits to the Museum necessarily became shorter and shorter, often only two or three days in length—days devoted for the most part to the verification of an innumerable mass of references to a mountain of books — while he left Mr Hinton to do some of the laborious comparisons of skulls and teeth, for which he had no longer the time. This collaboration has had the fortunate result that Mr Hinton is now available, and has kindly undertaken to finish the remaining parts of the *History of British Mammals.*

It may be a convenience to naturalists for the formal outlines of our author's life to be recorded here :—

Born 1871 ; only surviving son of Captain Samuel Barrett-Hamilton of Kilmanock, Campile, Co. Wexford, Ireland. Educated at Harrow (captain of football, 1890 ; played for Old Harrovians for several years). Trinity College, Cambridge (first class Nat. Sci. Tripos, 1894). Called to the Bar, 1896. Member of the Bering Sea Fur-Seal Commission, 1896-7. Served in the Boer War, 1901-2 ; Captain, 1902. Major 5th Batt. Royal Irish Rifles, 1905. J.P., Co. Wexford. Married 1903, Maud Charlotte, only daughter of F. S. Eland, Esq., of Ravenshill, Transvaal, by whom he leaves six children. Died in South Georgia, 17th Jan., 1914.

As a personality, Barrett-Hamilton was one of the most pleasant companions it has ever been our good fortune to meet. Warm-hearted, full of fun, known to all of us by a nickname, ready to engage in anything from a game of football at the back of the Museum to a discussion on nomenclature or dentition, the happy-minded lovable Irishman was a favourite with the whole staff of the Museum. Deeply will he be missed by all of us, and by none more than the writer of this short notice, who loses in him a dear and intimate friend of twenty years' standing.

OLDFIELD THOMAS.